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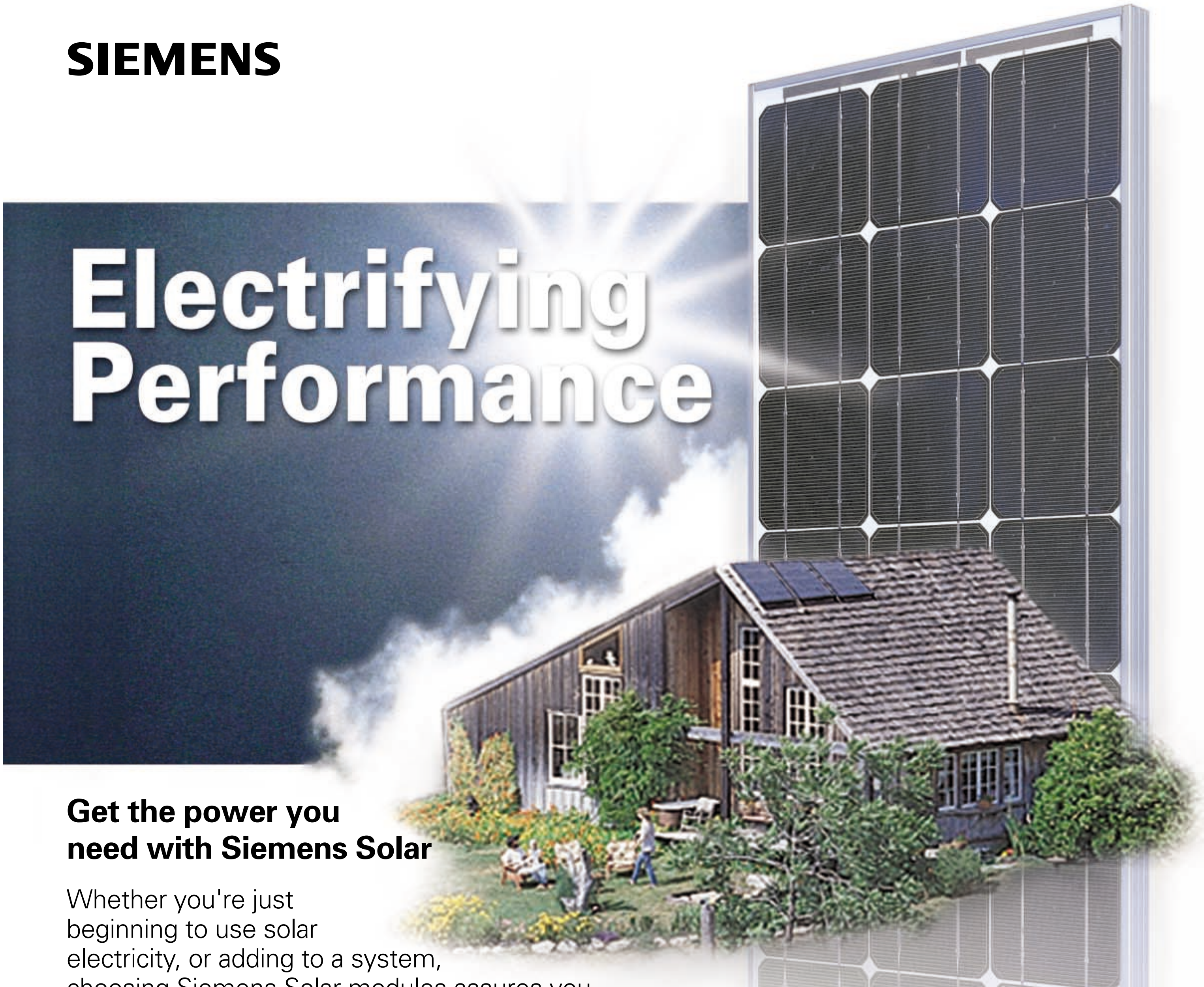
SIEMENS



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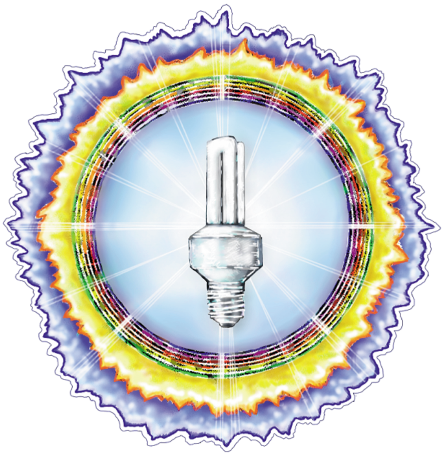
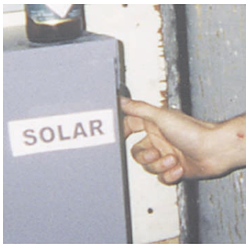


HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #80 December 2000 / January 2001

Features



10 **PV in the City**

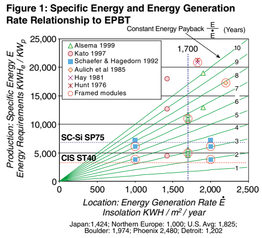
John Berton goes solar in the middle of Chicago. Collecting equipment over the years, he now meets all of his energy needs.

24 **Earth & Sky**

Peter Berney and Ariella Alandra build a beautiful adobe home in Arizona. Utilizing the sun for space heat and hot water, and sun and wind for electricity, their dreams have come true.

34 ***Intertie Hydro***

Kurt Johnson helps Kitty Couch offset her electrical loads by installing a simple batteryless hydro system. From Aqua Shear intake to the Harris Hydro output, it's a model installation.



42 **PV Payback?**

Not dollars, but watts—Karl Knapp and Theresa Jester count the calories in the PV production process and compare it to the output of the panel.

50 **Starting Out Small**

Rather than buying a bunch of test equipment, Rudy and Jill Ruterbusch just started out small. By monitoring their model system's performance, they can extrapolate their resource and design a full system.

Features

58 **Utility Intertie At SolWest**

Home Power *helps with a workshop on grid-intertied PV systems at the Grant County Fairgrounds in John Day, Oregon. But the local utility renegs on the net metering agreement.*

70 **SolWest, Part II**

The second year for this fair brought even more experienced nerds to Central Oregon for fun with the sun.

GoPower

76 **RE Vehicles at SolWest**

Electrathon racing came to the SolWest RE fair this year. Eric Hansen reports from the driver's seat. Also, biodiesel trippers show off their rig.

90 **More Electrathon**

Muscatine High School enters the race circuit with a new car and a new curriculum. The kids dig it.

96 **EV Driving Techniques II**

The second part of Shari's tips and tricks on piloting an electric vehicle.

100 **Box It Up**

Mike Brown finishes his series on mounting batteries in an EV conversion.

Cover: You can do it anywhere—John Berton's PV system in Chicago, Illinois. Photo by aerial-images-photo.com

RE Lab

84 **Experiment 1**

Battery acid test on welding cable insulation. Drake Chamberlin challenges the NEC's *ban on welding cable with real scientific method. They can't say no to empirical data—can they?*

Guerrilla Solar

82 **Guerrilla 0012**

450 watts of PV and 400 watts of wind provide more than just sell-back energy—emergency communications makes this guerrilla a true contributor to the community.

Book Review

122 **The Prize**

The history of oil—money, power, and corporate greed is explored by Daniel Yergin. Chris Greacen reviews this 900 page diagnosis of our worst addiction.

Columns

106 **Word Power**

"Renewable" ain't "alternative."

108 **Power Politics**

Paying the price—as the cost of energy goes up, the price goes way up.

More Columns

112 **IPP**

The meaning of the mergers, and more.

116 **Code Corner**

Voltage drop—beyond the code.

120 **Home & Heart**

Garlic, honey, and love.

128 **The Wizard**

Sun time is now.

136 **Ozonal Notes**

Mr. Manners challenges us to use good old-fashioned politeness as a model for our ecological behavior.

Regulars

8 **From Us to You**

80 ***HP*'s Subscription Form**

81 ***Home Power*'s Biz Page**

124 **Happenings—RE Events**

129 **Letters to *Home Power***

138 **Q&A**

141 **MicroAds**

144 **Index to Advertisers**

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Recycled Paper

Recyclable Paper

Makin' green power with renewables
Is pretty simple—there aren't many rules.
Eliminate those phantom loads
In shops, and boats, and in abodes.

Appliances that suck your power
Unbeknownst, hour by hour
It all adds up, it's plain to see
The goal here is efficiency.

Turn it off when you're finished with it,
Those watts add up, bit by bit.
You can make all the power you need to consume
If you turn off the lights when you leave the room.

First, check your loads—how much do you need?
How much juice do those appliances feed?
What's the voltage of the system, and how many amps?
"Volts times amps equals watts" is the dance.

Add it all up to figure how much you'll use.
Do the math and the homework—you're payin' the dues.
Once you've got your loads all checked
Scope out your source, Nature's in effect.

What's delivered to your door every day?
Is there sunshine, or wind, or water to play?
How much juice is comin' in, and how much juice is goin' out—
That's what this volt, amp, and watt thing's about.

Now go get the parts and put it together.
Wire it skookum and safe from the weather.
When you're hookin' it up, do it well, do it right—
Make your connections shiny and tight.

Take it one step at a time and you'll get it all set.
If you get stuck, there's lots of help, you can bet.
There are a lot of good folk with the answers you need,
Pick up a Home Power, peruse it and read.

Tread lightly on the Earth, plug in to RE sources,
Align yourself with the natural forces.
The goal is reduction in fossil fuel use,
So make those green amps, that clean sunshine juice!

–Joy Anderson for the Home Power crew

People

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Michael Welch
John Wiles
Dave Wilmeth
Myna Wilson
Ian Woofenden
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"Think about it…"

We don't know
who discovered water,
but we're certain
it wasn't a fish.
–John Culkin

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John Berton

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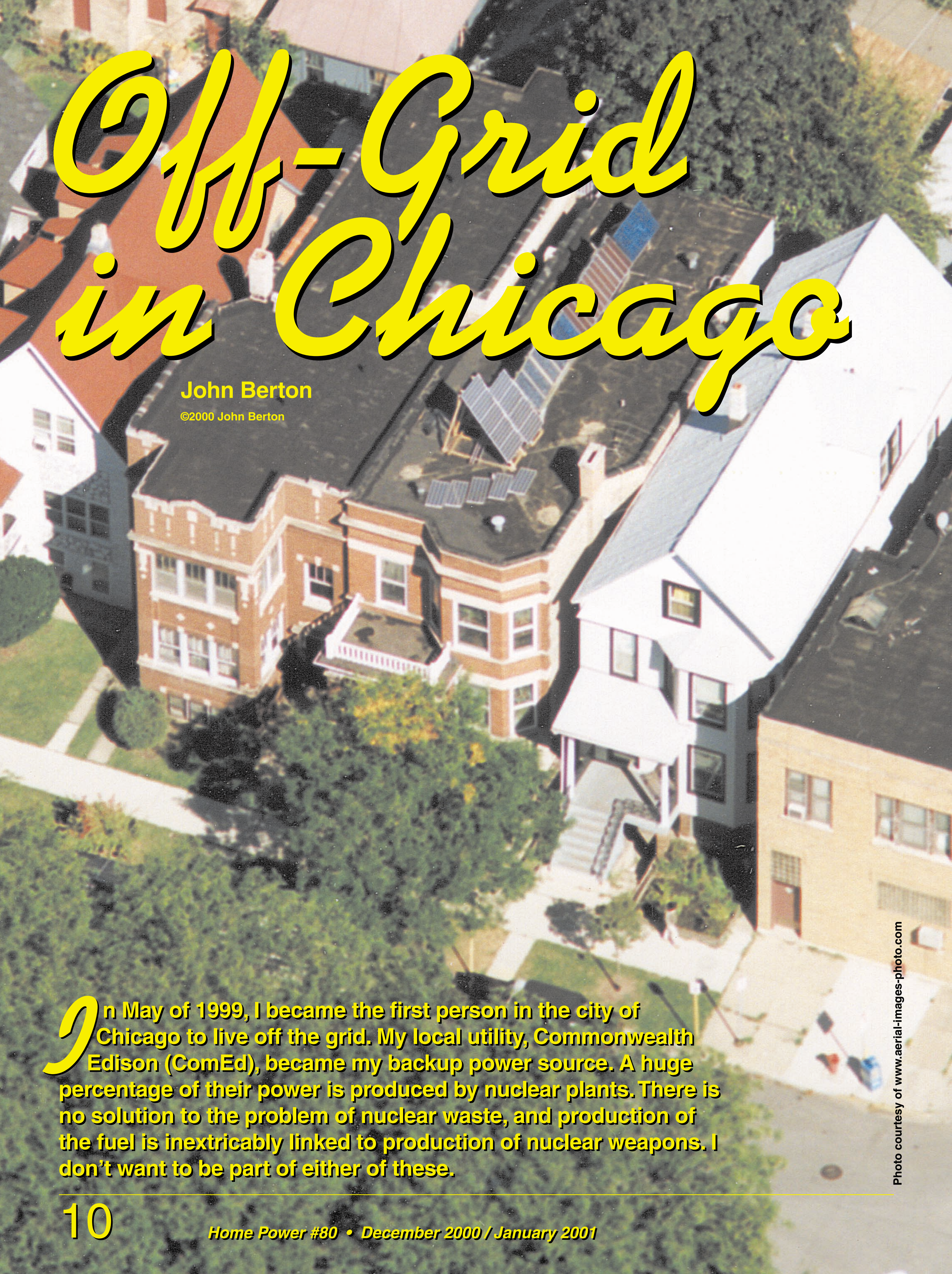


Photo courtesy of www.aerial-images-photo.com

In May of 1999, I became the first person in the city of Chicago to live off the grid. My local utility, Commonwealth Edison (ComEd), became my backup power source. A huge percentage of their power is produced by nuclear plants. There is no solution to the problem of nuclear waste, and production of the fuel is inextricably linked to production of nuclear weapons. I don't want to be part of either of these.

Not much visible from the street.

My dream started somewhere back in the late 1980s when I became aware of the possibility of generating enough electricity from photovoltaic panels to actually do something. Until then I had the assumption that you needed massive equipment to produce useful amounts of energy.

Renewable Inspiration

The very first seeds of my interest in power generation were sown in the late ‘70s, just after college. A college friend was involved in restoring a microhydro plant in southwestern Michigan. My roommate and I were invited to visit for a weekend. For me it was love at first sight. I was fascinated with the task at hand, the building, the people involved, and the setting.

Nothing else came of my interest in that microhydro project, but over the next decade I remained aware of power issues. My roommate became involved with the American Friends Service Committee. He spoke publicly about the problems of nuclear power in general and ComEd in particular. I listened intently, and slowly became aware of other possibilities for power generation.

At some point, someone mentioned *Home Power* magazine. There I learned that some people were producing enough power to perform useful tasks in a home environment. I was hooked. My first contacts in the renewable energy world were *Home Power* advertisers who had 800 numbers. I spent a year picking their minds and learning about equipment.

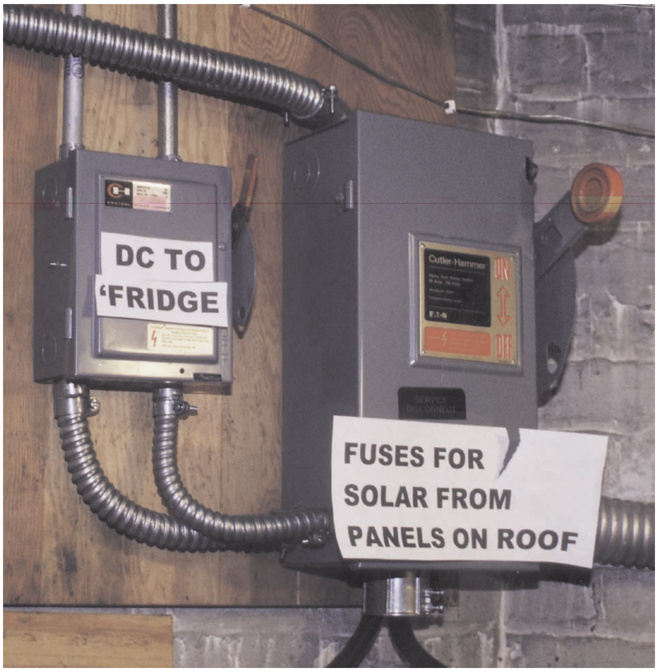
At the same time, I was trying to save money, and determining what changes I would have to make in my apartment to use home-produced electricity. I realized that I would not be able to power the entire apartment immediately, and decided to convert just the study and the refrigerator. In early 1991, I had enough money to begin collecting equipment.

Code Dilemma

When I began thinking of building a renewable energy system in Chicago, I wondered about city codes, inspections, etc. Since Mrs. O’Leary’s (legendary) cow kicked over the lantern in her barn back in 1871, we have had a history of zealous inspectors and rigidly—if unevenly—applied codes. I called the city department of buildings.

When I began to explain what I was doing, I was transferred. Each person and department transferred me to someone else. Finally

Almost all of the motley array of modules John collected over the years.



Left: DC distribution. Right: PV disconnect.

someone confessed, "We don't know what that is, and we don't have any codes on that." I thanked him and hung up. Except for the *National Electrical Code,* I was on my own. As long as I didn't burn the place down or electrocute anyone, I was free to do as I wished.

First Gear

I started with twelve Tri-Lams from the Carrizo Plains project in southern California, a Trace 2012 inverter, a set of old Edison nickel-iron batteries, and a Sun Frost refrigerator. I replaced the lights in my study with compact fluorescents.

All this equipment was delivered to my workplace—a traditional 9 to 5 real estate company in the Chicago suburbs. My co-workers thought I was nuts. I purchased #3/0 (85 mm^2) cable, #8 (8 mm^2) cable, conduit, a number of boxes, fuses, disconnects, and lumber for the panel mounts. Then I started the project.

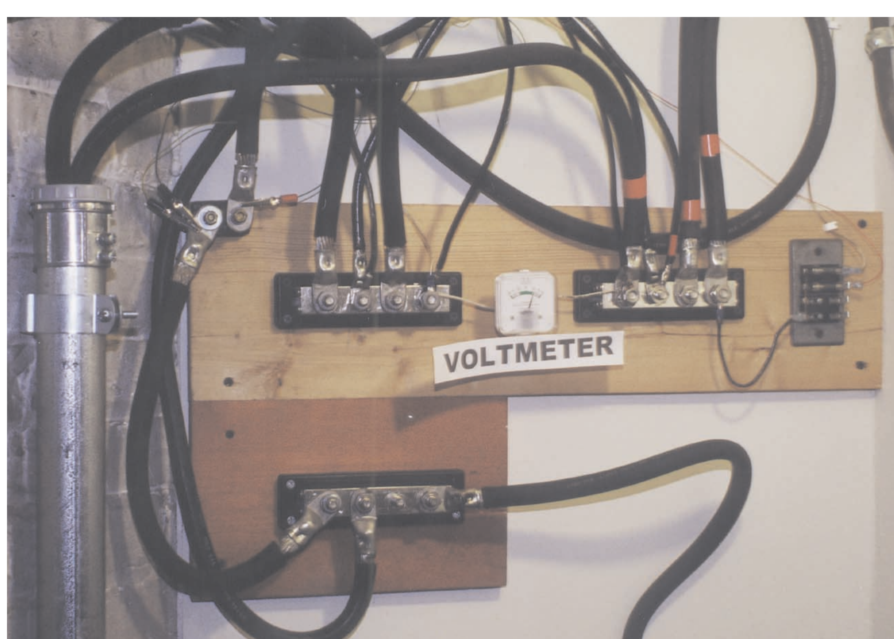
It was a task that took far longer than I expected. Had I known or stopped to consider how long and involved it would be, I might never have started. But I just plunged in with no definite plan other than an idea of how things were theoretically supposed to be hooked up. I started by building the racks. Everything had to be hauled up a 24 foot (7 m) ladder and through an 18 by 24 inch (46 x 61 cm) trap door to get to the roof.

The building directly south of me had a peaked roof that cast a shadow on my roof. I calculated the angle of the sun on December 21st, and figured as well as I could where that shadow would be then. I also needed to arrange the racks so that I could walk behind them to do seasonal adjusting. The space needed would put the panels in a shadow as the days in December grew shorter, so I made the racks 15 inches (38 cm) higher to keep them in the sun.

Panels were wired together on the roof after being installed in the frames. Perhaps the most difficult part of the job was getting two #3/0 (85 mm^2) non-welding cables through 60 feet (18 m) and four 90 degree bends of 2-1/4 inch (5.7 cm) conduit by myself. The 2-1/4 inch conduit runs from the junction box on the roof, over the parapet, and down the wall to the basement, where it goes through a boarded-up window into the battery room.

I ordered the first set of batteries from Utility Free in Colorado (no longer in business). They arrived well battered and leaking electrolyte. There was no problem returning them to the shipper. A second shipment arrived in excellent condition. I unloaded them from the truck and lugged them into the basement. A battery rack was the next order of business. I used 2 by 8 lumber and metal shelf supports (L-brackets). Then I installed a fused disconnect for the array and a breaker for the inverter.

Main DC bus bars.

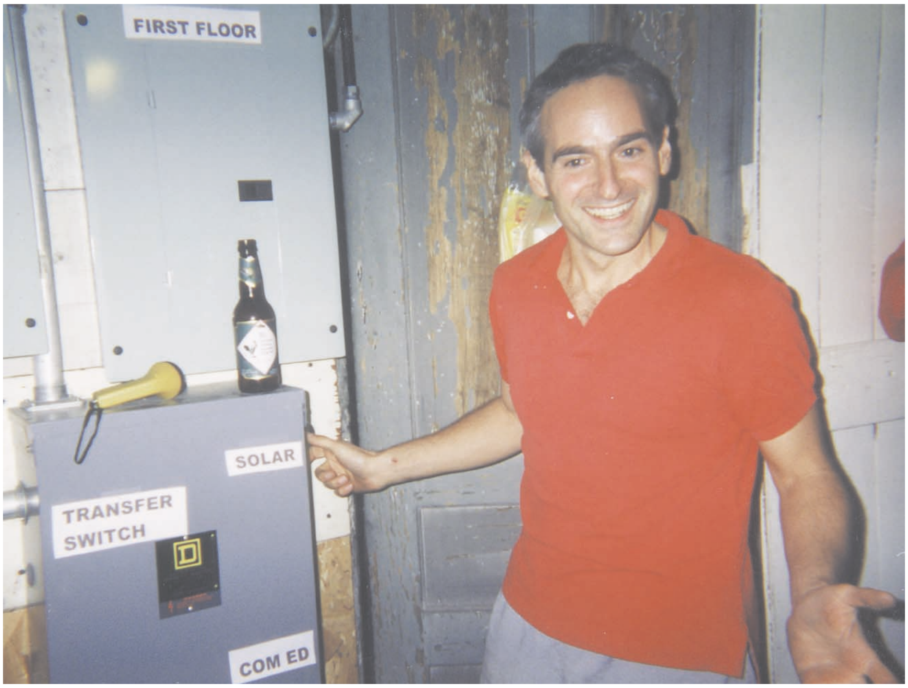


It Actually Works!

The Sun Frost had arrived earlier, so I had two refrigerators in the kitchen. Once the panels were connected to the batteries for a few days, the voltage remained well over the 12 volts necessary. The Cruising amp-hour meter showed that the batteries were full and overcharging.

I connected the wires from the Sun Frost to a fused switch on the system in the basement, ran upstairs, and listened. The compressors kicked on. I was amazed. It really worked!

Sometime during the next week, the Trace arrived. I installed it on the rack right next to the batteries in the basement. I separated them with a piece of wood to protect the inverter from corrosive fumes.



Author John Berton switches to solar power.

The giant print on the terminals and the even larger plus and minus signs, the cost of the inverter, and the warnings in the manual made me check and recheck my wiring. Convinced that I had installed things correctly, I gingerly attached the #3/0 (85 mm^2) cables to the inverter. Nothing happened. I plugged my drill into the Trace. I was ecstatic—I couldn't believe that it actually worked! This was real 120 V power. This was what I needed to run the whole apartment. The system functioned perfectly—it ran two lights in my office, computer, printer, boom box with CD player, dual tape deck, and an AM/FM radio.

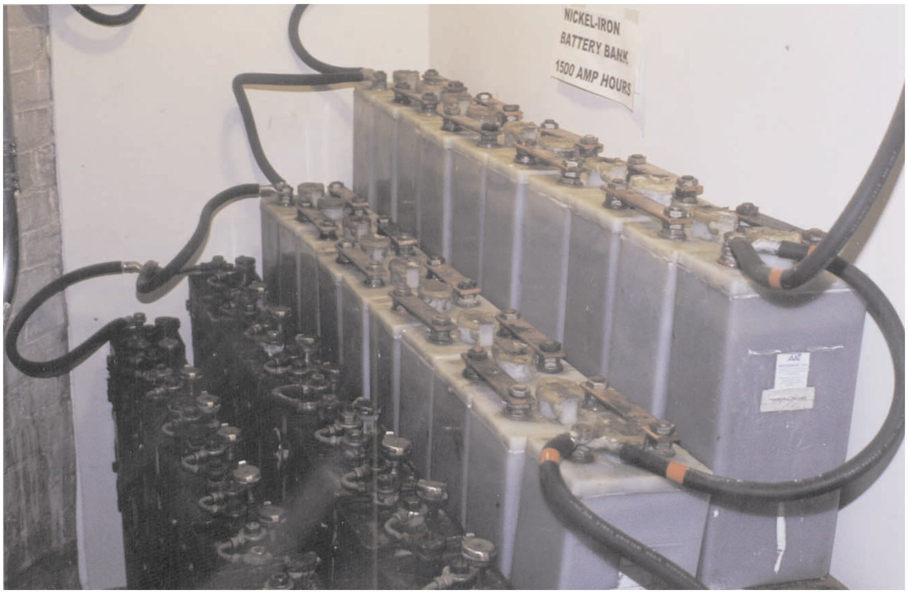
From time to time over the next nine years, the batteries got low and the Trace would charge them from the grid. The batteries functioned flawlessly. I watered them every three to four weeks. The only problem was that I didn't have a charge controller. The nickel-iron batteries didn't care about being overcharged. It didn't hurt them. I just had to add water more frequently. Adding a charge controller would just increase costs, and I was running out of money.

On sunny days, the batteries would go over voltage at about 11 am and the Trace would shut off. This was annoying if I happened to be home during the day and working in the study. So I planned to add a charge controller.

Nickel-Iron Batteries

When I go to energy fairs and talk to people about batteries, they worry about overcharging, equalizing charges, sulfation, and reduction of battery life by taking too much power out of the pack. They also need to be concerned about the age and size of batteries if they want to add to their lead-acid battery pack. When I first started planning a renewable energy (RE) system, the

Nickel-iron cells: Twenty Russo-Hungarian (top) and thirty Edison (20 shown).



Close-up of a 30 year old Edison NiFe cell.

idea of taking care of lead-acid batteries was daunting. None of these things are a concern with nickel-iron batteries.

Nickel-iron batteries are not harmed by being overcharged. They don't need equalizing. You can add to the nickel-iron pack with any size battery of any age at any time. And, according to the supplier, they last forever.

The drawback was that they cost about three times as much as lead-acid batteries. Their energy density (power per pound) is half that of lead-acid batteries. Their internal resistance is greater, making it harder for them to give up large amounts of energy as fast as lead-acid batteries. And they tend to self discharge faster than lead-acid batteries.

Last but not least, they were not being produced anymore. The only ones available were at least twenty years old. But I was assured that they had many years of life left. The advantages seemed to outweigh the disadvantages.

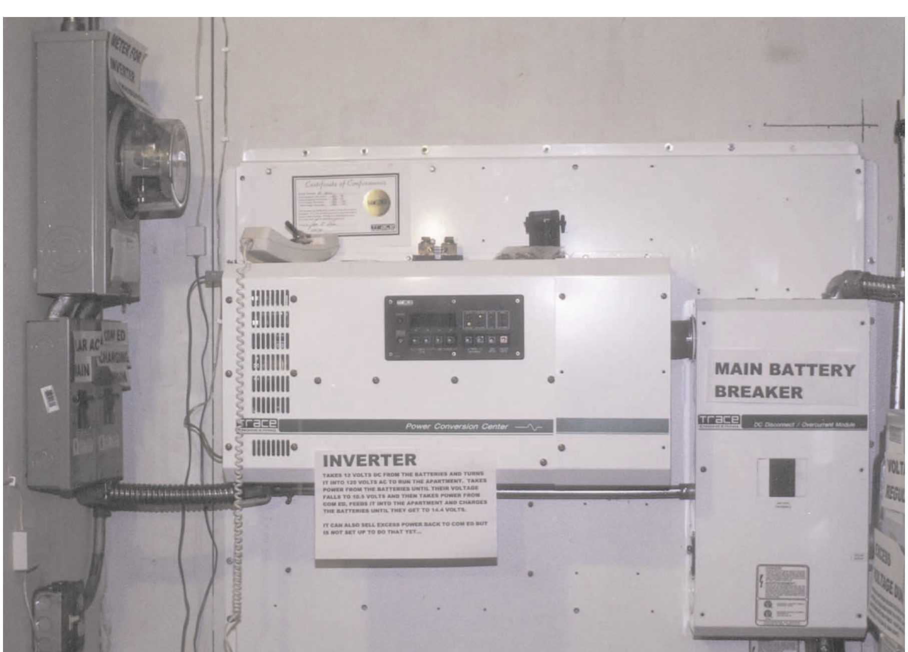
The recommended way to store nickel-iron batteries is to discharge them completely and put them away. You can come back years later and charge them up. They never need equalizing. I have never experienced any problem with overcharging.

Watering them happens much more frequently than with lead-acid batteries, but this is not much of a drawback. There are precipitous voltage drops under heavy loads, but this has not yet been a problem. Carbonation of the plates or electrodes is supposed to be a problem, but has not happened yet.

Not only would I use nickel-iron batteries again, but I would probably not want to set up a new system without them. The idea of using lead-acid batteries after the ease of nickel-irons is horrifying.

The problem is that the only new NiFe batteries available are produced in Shanghai, China or St. Petersburg, Russia. Shipping is prohibitively expensive. Power Technology Systems is rumored to be trying to produce a North American nickel-iron battery, but nothing has happened yet. Nobody in the U.S. that I am aware of has any of the new batteries in stock. And I'm unaware of any used ones currently available.

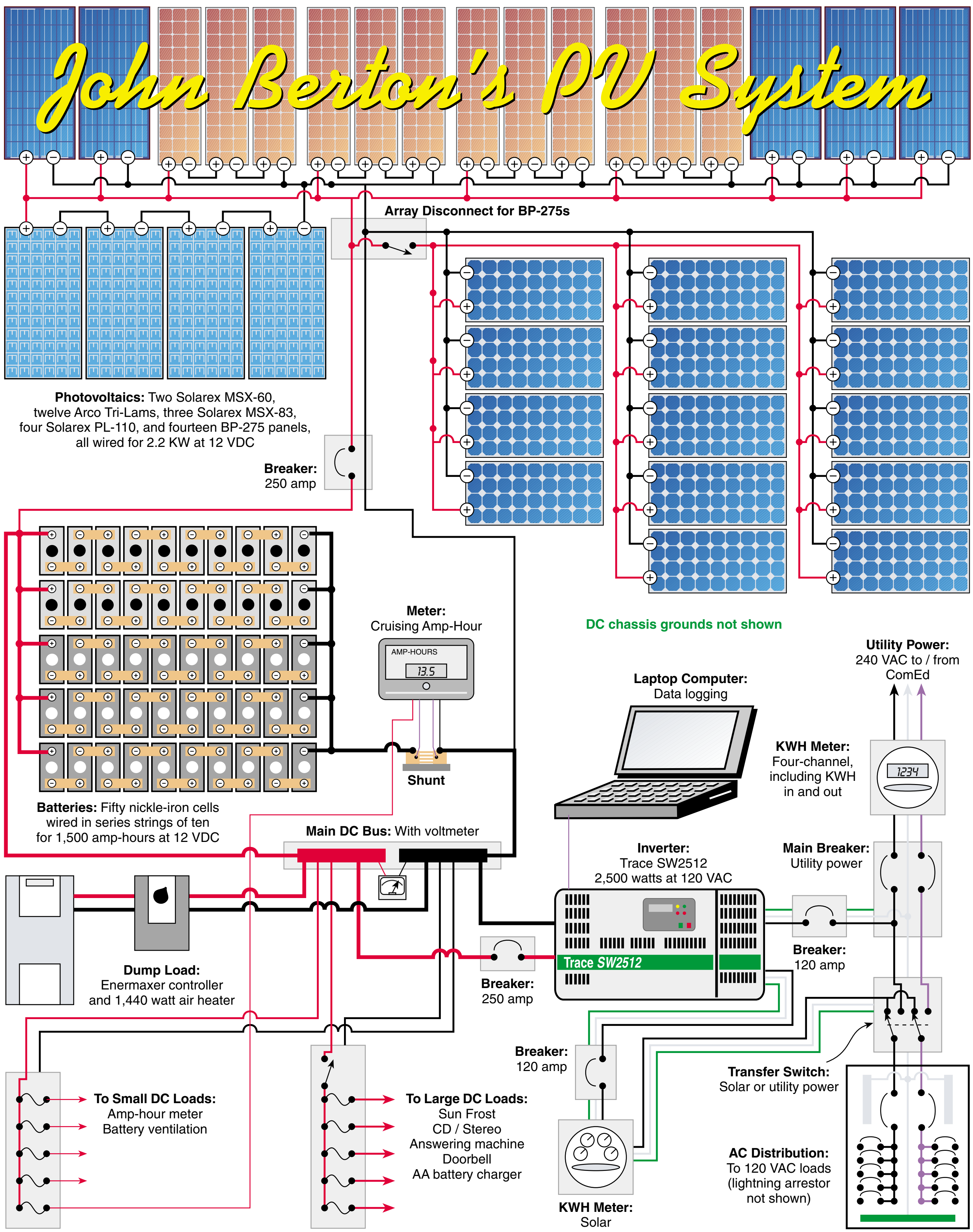
KWH meter shows solar energy produced (left); Trace 2512 inverter.

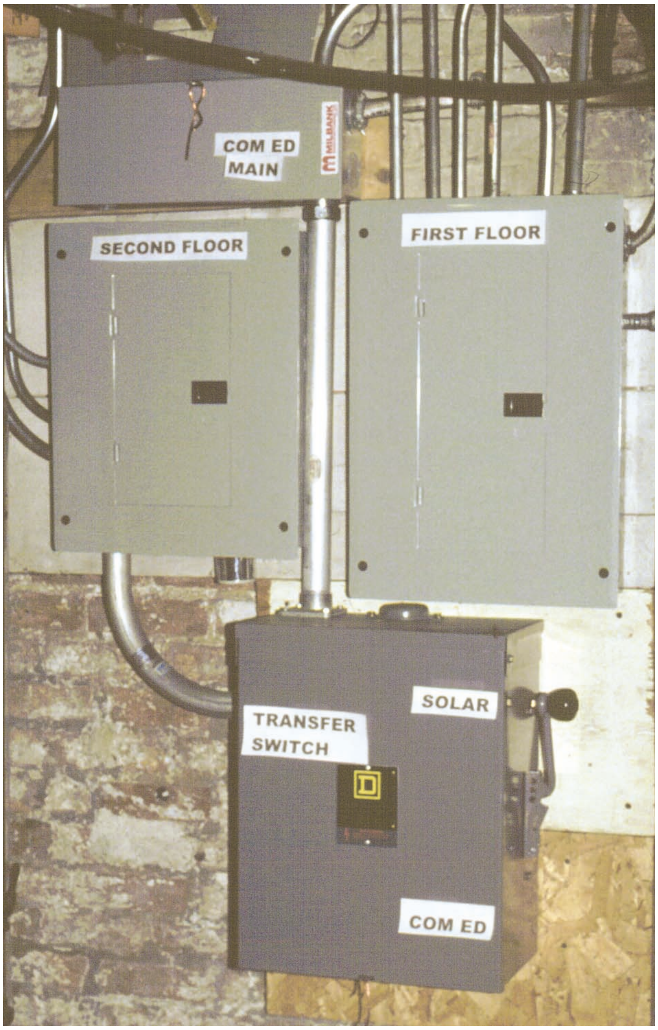


Off to the Midwest RE Fair

When I was first getting my system set up, all contact I had with the renewable energy crowd was via 800 phone numbers. In the spring of 1992, after living with my system for almost a year, I attended my first energy fair in Amherst, Wisconsin (MREF), put on by the Midwest Renewable Energy Association. The range of equipment available, the people and their experiences, and the workshops, were fantastic.

John Berton's PV System





Renewable energy or the grid—notice the position.

Over the next eight years, I went to the fair every year. As money became available, I purchased more equipment. Two MSX-60 panels one year. Three MSX-83 panels the next. Four ancient Solarex panels, a Trace 2512 inverter and control panel, an Air 303, fourteen BP-75 panels, an Enermaxer, two more strings of 30+ year old Edison batteries (300 AH each). Twenty brand new Russian-made nickel-iron batteries (300 AH each). Two 3 by 8 foot (0.9 x 2.4 m) panels to heat water, and two to heat air. Another Sun Frost.

Some people spend US$40,000 on a new SUV, and nobody questions them. I chose to spend close to that on my solar-electric installation, and was seen as eccentric.

Time & Money Merge

Much of this equipment spent literally years on my living room floor waiting for its companion equipment to be purchased. Then it spent more time waiting for me to find time to begin installation. A standard joke developed among suppliers at MREF. When they met me intent on making another purchase, they would ask if I had managed to install the stuff from three years ago. In the spring of 1999, time and money finally came together. I also swore to get the system installed before the 1999 fair.

First I changed all the bulbs in my apartment to compact fluorescents. I eliminated any phantom loads I found by using power strips and rechargeable AA batteries.

I was unable to install the new Trace alone, but I determined I could go off the grid with the old 2012 if I could just get the new batteries and panels installed. It was a lengthy procedure and went off largely as planned except for a scary battery explosion. As I was lifting the old Edisons onto a platform, something inside one of them shorted and with a loud noise sent a corrosive plume into the air. I happened not to be leaning over that battery at the time.

It was a good thing, since I was not using protective eye gear. My mind instantly recalled Richard Perez' story about exploding batteries. To this day, any time I look into my batteries, I have my goggles on. My vinegar is also close at hand (my batteries are alkaline, so baking soda is not the neutralizer).

When finally assembled, the battery pack seemed not to hold a charge well. I conditioned them by charging them twice with my Trace 2012 as much as I could, and then discharging them. They then held a charge and functioned as expected.

The Trace was still feeding only one circuit in my apartment, but I was now technically off the grid. Grid power was still available at every wall outlet and in overhead lights, but I didn't use it. I had long orange extension cords snaking their way throughout my apartment from the one circuit that was powered by the Trace. Clamp lights and power strips were everywhere. All my power came from my Trace. At the energy fair, I could honestly say I was off-grid.

Wind Power

I spent a long time at the fair talking to the people from Southwest Windpower about mounting an Air 303 without actually attaching it to the building. I had concerns about noise and vibration.

As an experiment, I designed a mount that would be anchored by sandbags. The base measured 22 by 22 feet and was 13 feet tall (6.7 x 6.7 x 3.9 m). In some places, on top of a two story building, this might be adequate. Not so in my neighborhood of Chicago. I had a two story building just north of me and a two story building with a peaked roof south of me. The peak of

that roof was 10 feet (3 m) above my building, giving me only 3 feet (0.9 m) of clearance.

Adding to my problems was a giant cottonwood tree well over 80 feet (24 m) tall across an alley just east of my building, and a row of three story apartments across the street. These proved to be enough to make my Air 303 almost useless unless there was a constant northwest wind. The solution would be to raise the turbine another 10 to 30 feet (3–9 m).

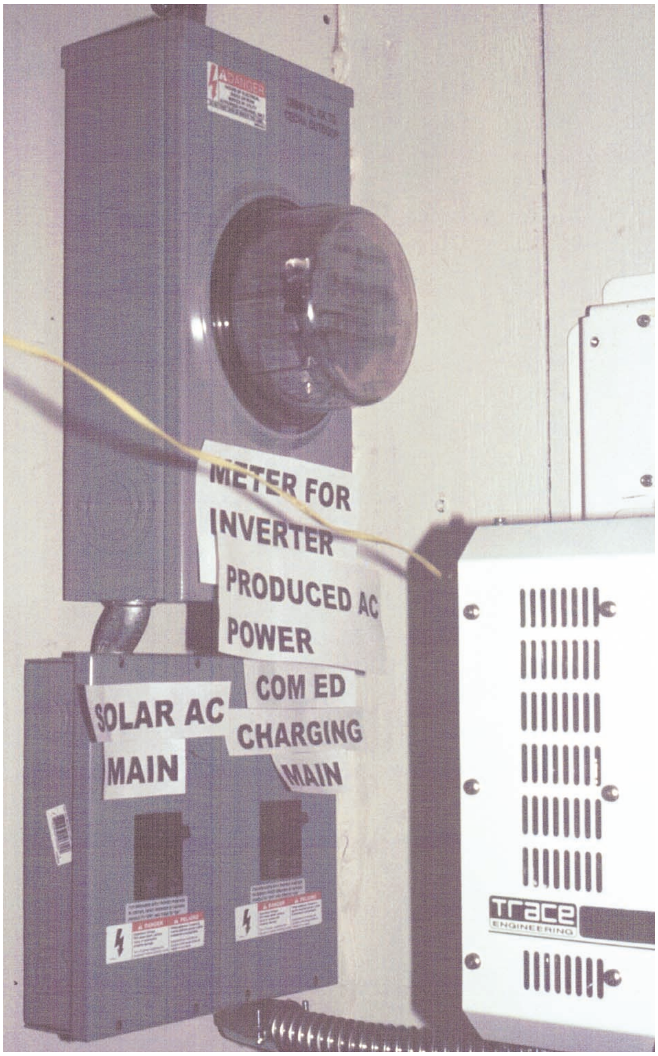
So far, the noise was negligible compared to the roar and shaking of city buses, ambulances, trucks, and general street traffic just two houses away on Lawrence Avenue, a major four-lane east-west artery. I was told, however, that once the Air 303 started to self regulate in strong winds, the vibration and noise would become intolerable.

I am unsure about whether the sandbags would have supported an additional 30 feet (9 m) of tower, or how to attach more cables. I concluded that the time and expense would be better spent on additional photovoltaic panels, so I decided to take the Air 303 down. A taller tower was the solution. But the effort to do this, the maintenance necessary, the possible conflicts with city ordinances, and potential problems with neighbors if the thing fell during a storm influenced my final decision.

Pull the Plug Party

One day during the summer of 1999, I returned to my apartment to see a group of my neighbors gathered in the alley behind my garage, chatting with each other. I pushed the button to open the garage door. They were quite surprised. There was a power outage in my neighborhood, the first of many in Chicago that summer. None of them had power, nor would they for hours.

The Air 303 just didn't have the exposure it needed.



All solar energy is counted with a KWH meter.

They were already aware of my efforts to produce power and that I had "some equipment" on the roof. But suddenly they realized what it really meant that I was producing my own power. I ran an extension cord to my building partner's refrigerator (she also has a Sun Frost RF-16 but hers is 120 V). She disconnected the extension cord when power came back on.

By late summer, I still had not finished the installation. I decided to have a "Pull the Plug" party to celebrate being off the grid. I wanted to have the system really finished so people would not be tripping over extension cords. The date of the party forced me to get the system finished.

My friend and electrical consultant, Vladimir Nekola (see the cover story of *HP46),* came over and had me

change a number of things that I had wired. He also helped me install the Trace SW2512, Enermaxer, resistor dump, meters, and disconnects.

The final task was to wire the whole system into the breakers for my apartment through a disconnect that would, in emergencies, send grid power back into my apartment and disconnect the solar power. We finished one day before the party—just enough time to stock the Sun Frost with beer and pop. The highlight of the party was to be "the only solar-cooled beer in Chicago."

Dealing with the Surplus

I have recently started selling back to ComEd. ComEd has instituted a program to buy back power from people like me. There is a special meter that they have installed, and an external locked switch they can throw if they need to work on lines in the area.

It's not ideal for me, however. I want the inverter to sell back to ComEd only when the batteries are full. So I want the charge controller, instead of shunting the power to a resistive load, to send it to the utility. When the batteries get low, I want the inverter to stop selling solar power and redirect it back to the batteries.

I want the house to be powered from the batteries *all the time,* unless the batteries are low *and* there is no sun. At that time and only at that time do I want the inverter to take grid power to charge the batteries. I have talked to Trace. They say the inverter I have can't do that. Right now I sell to ComEd only when I'm home and can get out of "sell" mode when the sun goes down. This seems complicated. I hope I have misunderstood Trace and that someone can tell me how to do what I want to do.

Future plans include a car charging station in my garage, and an electric truck. The truck has been purchased, as well as all the parts necessary for the conversion except the batteries. Construction of motor and equipment mounts and battery boxes, lack of welding experience, and a host of other problems have delayed this project. I hope to have it completed by Spring 2001.

I have purchased more panels that are not yet installed. These, added to what I already have, should allow me to recharge the truck. I hope to eventually stop selling excess power back to the utility, and instead use it myself—recharging electric vehicle batteries.

Berton System Loads

#	*Item*	*Watts*	*Average Hours / day*	*Average WH / day*	*%*
1	Food dryer	260	8.00	2,080.00	38.7%
1	Sun Frost RF-16	120	6.30	756.00	14.0%
1	Blender	1,000	0.14	142.86	2.7%
1	CD player & radio	15	5.00	75.00	1.4%
1	Fountain	3	14.00	42.00	0.8%
1	Answering machine	2	24.00	38.40	0.7%
1	Stereo & turntable	30	1.00	30.00	0.6%
1	Food processor	400	0.05	20.00	0.4%
1	Vacuum cleaner	750	0.01	8.93	0.2%
1	Iron*	1,100	0.00	3.27	0.1%
1	Juicer*	300	0.00	0.14	0.0%
1	Coffee grinder*	110	0.00	0.05	0.0%
	Lighting				
3	Study, CF	23	5.00	345.00	6.4%
2	Kitchen, CF	23	3.00	138.00	2.6%
5	Dining room, CF	23	1.00	115.00	2.1%
4	Bedrooms, CF	23	1.00	92.00	1.7%
4	Living room, CF	23	1.00	92.00	1.7%
4	Hallways, CF	23	1.00	92.00	1.7%
3	Bathroom, CF	23	1.00	69.00	1.3%
2	Closets, incand.*	75	0.00	0.22	0.0%
	Computer Equipment				
1	Dell laptop	66	10.00	660.00	12.3%
1	Desktop computer	400	1.00	400.00	7.4%
1	Printer	60	0.29	17.14	0.3%
1	RW CD-ROM	100	0.14	14.29	0.3%
1	AT&T laptop	60	0.14	8.57	0.2%
1	Scanner	50	0.14	7.14	0.1%
1	ZIP drive	13	0.07	0.93	0.0%
	Power Tools				
1	Circular saw	1,560	0.03	52.00	1.0%
1	Router	1,200	0.03	40.00	0.7%
1	Drill	660	0.03	22.00	0.4%
1	Reciprocating saw	581	0.03	19.36	0.4%
			Total average watt-hours per day	5,381.31	

*Average daily use is too low to show at two decimal places.

Off-Grid in the City

My power bills initially didn't change because the utility had not been out to physically read the meter for almost two years. I was getting estimated bills. When they finally read the meter, I had been seriously overcharged. There is a minimum charge just for being connected. There are also decommissioning charges for the nukes that they have. These charges run between US$7 and $10.

Instead of refunding the money that I had been overcharged, they are gradually reducing it by applying the monthly charge against what they owe me from the overcharge. So, for now, I have a zero bill. Eventually, I will pay the connection charge and whatever else they deem necessary to keep me connected.

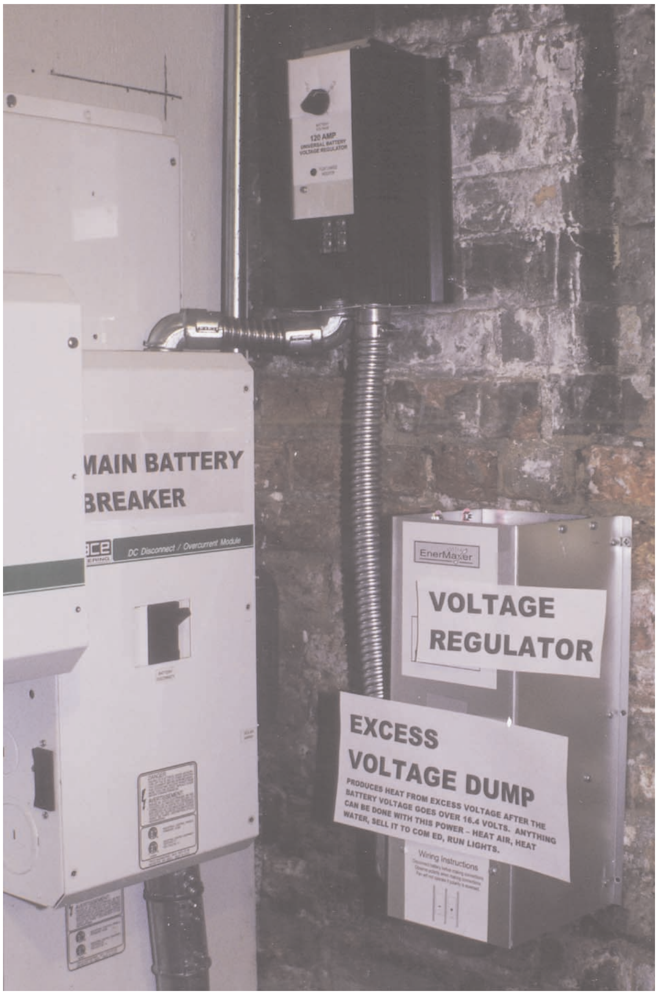
My apartment has now been off-grid for a year. The inverter switched me back to grid power once in December after many days without sun. It happened again in early February. I am now trying to convince my building partner on the first floor that self-made power is reliable. She already has a Sun Frost and compact fluorescent bulbs. She only needs to buy into the idea of conservation to make this the first entire building off-grid in the city of Chicago.

I knew nothing about solar power and very little about electricity when I started. Now I can't imagine living without solar power. In any moves I consider, I always have the question of solar power in mind. Will this building be easy to convert to solar? How is the roof situated? Are there any obstacles to putting up panels? Is it the kind of neighborhood where the neighbors will complain?

Solar Anywhere

Since I have done this in Chicago, I believe I can do it just about anywhere. We don't have the best situation for solar, but it works. But this also poses a dilemma. Sometimes I consider moving somewhere just for a year, like Paris, or Oslo, or Peking. How would I rent out my apartment with the solar-electric system?

I've learned what it takes to supply my energy needs and satisfy my philosophical stance. I'd need to find someone truly committed to being off the grid. Someone to care for the system, water the batteries, and be able to go to the battery room and talk to the equipment. Someone who does not need air conditioning (that's hard for some people in Chicago). Someone who can turn off lights, and spend more for replacement bulbs when the compact fluorescents go out. It would have to be someone who's generally aware of power usage, or someone who's willing to learn.



Enermaxer dump load.

It's not as carefree as utility power in the short run. But you get a guilt-free conscience when ComEd starts moaning about their nuke liabilities and the rate hikes that are necessary for their upkeep and eventual decommissioning.

Solar panels are ideal for urban environments. Flying over most large cities, I'm amazed by the square footage covered by roofs. Covering large areas of desert with solar panels, taking energy from waves, building dams, and even harvesting power from the wind somehow changes the environment from which the power is being taken. Whether the change produced is significant is debatable. Someone may someday discover that we are irreversibly changing certain micro-environments to the detriment of their inhabitants.

By covering urban roofs with PV, we can reduce the amount of land we need to devote to power production/collection. Of course, reducing need is still the best solution—even for urban PV-created power.

Access

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773-334-7529 • JBerton55@cs.com

Vladimir Nekola, Nekolux, 1433 West Chicago, Chicago, IL 60622 • Phone/Fax: 312-738-3776
vladimir@nekolux.com • www.nekolux.com • Great advice, support, wiring

Backwoods Solar Electric Systems, 1395 Rolling Thunder Ridge, Sandpoint, ID 83864 • 208-263-4290
Fax: 888-263-4290 or 208-265-4788
info@backwoodssolar.com • www.backwoodssolar.com
12 V Sun Frost RF-16, various gauges and meters

Vertis Bream, Energy Options, 1755 Coon Rd., Aspers, PA 17304 • 717-677-6721 • Fax: 717-677-6466
New and old nickel-iron batteries

Great Northern Solar, Christopher LaForge, 77450 Evergreen Rd., Suite #1, Port Wing, WI 54865
Phone/Fax: 715-774-3374 • gosolar@win.bright.net
PV panels, tracker

Jim Kerbel, Photovoltaic Systems Co., 7910 Hwy 54, Amherst, WI 54406 • 715-824-2069 • PV panels

Abraham Solar, 124 Creekside Pl., Pagosa Springs, CO 81147 • 800-222-7242 • Phone/Fax: 970-731-4675
Trace 2012 and original Tri-lams

Applied Power (formerly Alternative Energy Engineering), PO Box 339, Redway, CA 95560
800-777-6609 or 707-923-2277 • Fax: 800-777-6648 or 707-923-3009 • info@appliedpower.com
www.solarelectric.com • Enermaxer and dump load, Cruising meter, switches, fuses

Electro Automotive, Mike Brown, PO Box 1113-HP, Felton, CA 95018-1113 • 831-429-1989
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Of Earth...

Peter Berney

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Peter Berney and Ariella Alandra's adobe home is powered by the sun and wind, and uses solar energy for space heating, water heating, and greenhouse gardening.

For many years I had wanted to design and build my own home. I wanted to demonstrate that a person could have a beautiful home that would fit into its landscape and be energy efficient, inexpensive, free of toxic substances, and a pleasure to live in. Ten years ago, I began to fulfill that dream.

The result is a house still in the final stages of construction, but one that relies on the sun for heat, hot water, and electricity. Two wind generators supplement the supply of electricity.

Soul Building

My desire to do everything myself—from pouring adobe and cement to building my windows and doors—has made this process a long one. Searching for sandstone to build a hearth wall and reusing old flooring to build cabinets are time consuming but enjoyable tasks that enliven the soul.

The four acres of land that I purchased was far from any power lines, encouraging my interest in using renewable sources of energy. The site receives plenty of wind, and the sunshine here at 5,000 feet (1,525 m) is seldom interrupted for more than a day.

I began by building a woodworking shop of poured adobe. It would eventually be insulated on the outside and then stuccoed. I purchased sixteen used Arco M-51 panels and set four of them up with four L-16 batteries and a Trace 2524 inverter. These ran my shop adequately.

In my woodworking shop, I run a table saw (1.5 hp), an 18 inch bandsaw, a 6 inch jointer, lathe, planer, drill press, and a wide variety of other power tools. I do this all without difficulty, and often work all day in the shop.

and Sky

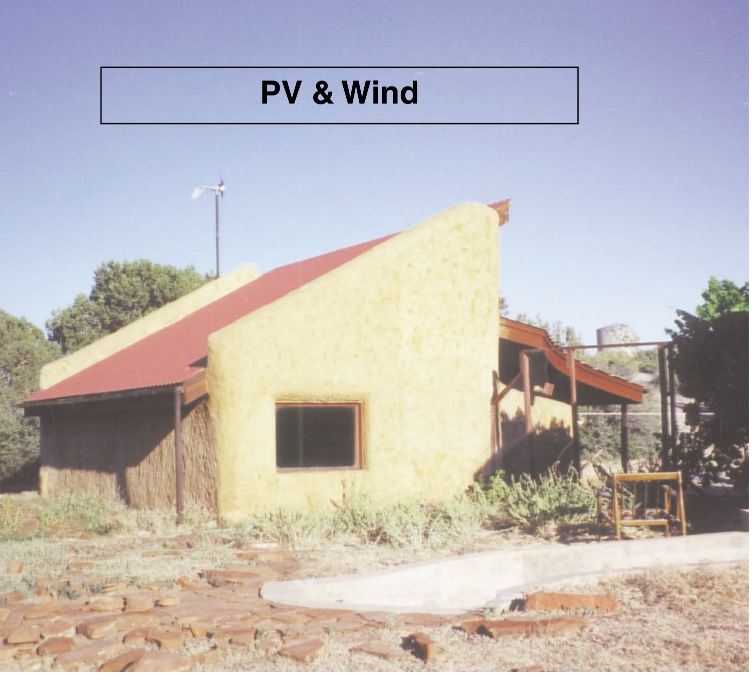
The shop contains the renewable energy system.

After roofing the shop with steel panels, I began on the house. The house is a U-shape surrounding a 400 square foot (37 m^2) greenhouse. It is built in the same manner as the shop, with 16 inch (40 cm) poured adobe walls that are insulated on the outside and stuccoed. It is bermed 3 feet (0.9 m) high on the north side. The only room that does not open to the greenhouse is one of the two bathrooms. But I designed it so there would be plenty of space and light for plants to grow and purify the air.

The house is very light and airy. On moonlit nights, I can walk anywhere without turning on lights, even into the circular shower that has its own skylight and built-in dressing room. The dining room and kitchen face to the southeast. It's delightful to have breakfast while sitting in the sunshine.

Shop & House

The shop is bermed to 4.5 feet (1.4 m) on the north side, and the temperature is pleasant any time of the year. It depends only on the sun to heat it, and the adobe walls to store that energy. The batteries and inverter (now a Trace 4048 sine wave inverter) are at home in the shop, well protected from dust, and vented to the outside.



The shop, with one of the Air 303s spinning.

Precious Water

In Arizona, water is a precious commodity. The well I originally had dug intercepted a water-bearing layer at 95 feet (29 m), but it only produced a half gallon (2 l) a minute. I pumped water, with an assortment of pumps, to a 3,500 gallon (13,250 l) tank. The tank is on a hill about 20 feet (6 m) above the house. This gives us about 10 psi pressure. And as the tank fills, the pressure rises enough that you can judge the amount of water in the tank by the flow from the shower head.

The first pump was a Flowlight Slowpump, powered by four M-75 panels on a Zomeworks tracker. This pump sat above the water table. But it was easy to pump the water level below the pump's intake level. This meant that the pump sucked air, which is hard on it. After pulling the pump by hand five times for repairs, I bought a submersible pump to replace it. I found that I would pump the well dry every summer watering my garden, and then have to wait six weeks for more water.

Over several years, I had to pull this pump myself for more repairs. I became so frustrated that I purchased a jack-type pump three years ago. I figured that I could at least work on the electrical and mechanical parts without much effort. I also had the well deepened another 120 feet (37 m) to a more reliable aquifer that produces 6 to 7 gallons (23–27 l) a minute. Because I can only pump 1/2 gallon (2 l) a minute, I have not been able to lower the static 95 foot (29 m) water level with any amount of continuous pumping.

I have the pump connected to the batteries, and can pump at night or in cloudy conditions by engaging a bypass switch from the batteries. The pump is connected to the batteries on a line that is fed by the five M-51 panels and the two wind generators. This line feeds through the Trace C-40, which allows electricity to flow only into the batteries, not out. If I want to pump when the panels and wind generators are not producing enough electricity to run the pump, I have to bypass the C-40.

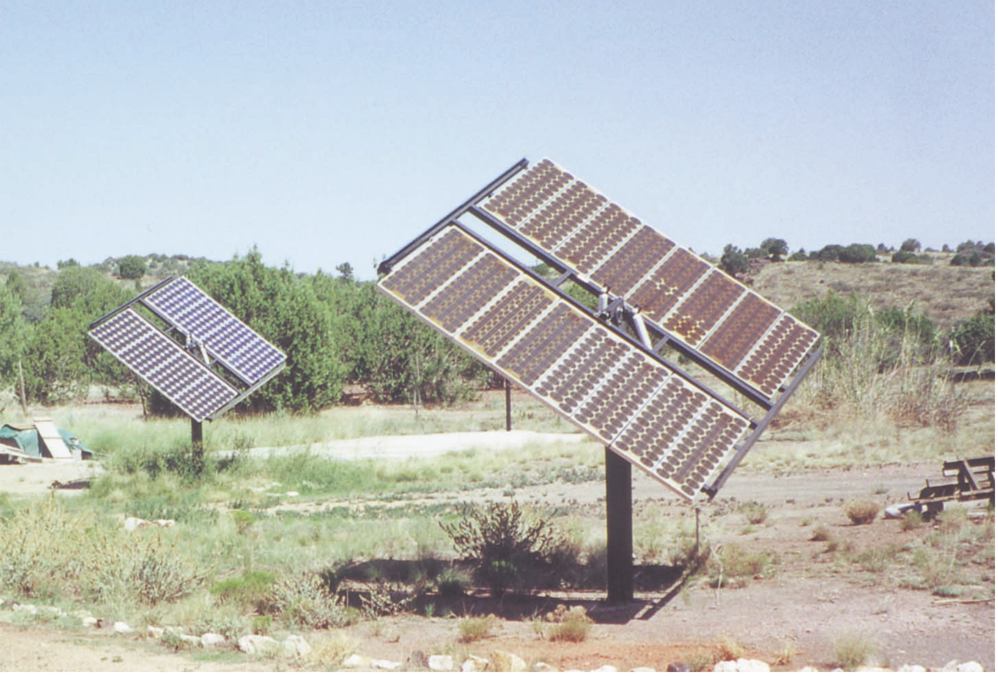
In the shop, I added a pressure pump that pressurizes the water for the house and shop whenever I want to use the washing machine or dishwasher. Otherwise, the pressure is fine. I plumbed the house using 3/4 inch copper pipe to minimize water pressure losses.

Heat & Hot Water

The "big fin" Zomeworks panels in the greenhouse heat water that rises by convection into a solar storage tank. The panels have extruded aluminum fins that are painted black, and have a channel on the back that snaps over 3/4 inch copper pipe. Each of my twenty-four panels are 6 inches (15 cm) wide by four feet (1.2 m) long. Although Zomeworks does not produce these anymore, they do have some extruded fins in 8 foot (2.4 m) lengths still available. I have found these fins to be efficient, and they require no care other than a good cleaning every few years.

A fireplace in one bedroom also doubles as a supplemental heater for domestic hot water. In the winter, when the days are short and we have had several consecutive cloudy days, I burn a fire in the bedroom fireplace. This heats the room, and also heats

Inside the central greenhouse.



Eight Siemens SP75s and sixteen Arco M-51s on Zomeworks trackers on the north side of the house.

water that moves into the storage tank by convection. In about half an hour, I have me enough water for a nice hot shower.

The adobe walls soak up heat so efficiently that you cannot overheat the bedroom by burning a fire in the fireplace. Temperatures in the house vary more widely than those in the shop. The large greenhouse cools at night, often leaving the rooms in the low sixties during the winter at dawn. A woodburning stove placed against a sandstone wall and chimney remove the chill.

I designed the house so that the sun shining through the greenhouse heats the adobe walls, which then pass the energy at about an inch per hour into the house itself. The U-shape of the greenhouse means that the sun is always shining on at least one wall.

A large amount of glazing on the south side of the house allows the sun to penetrate into the house all winter, and in early morning or late afternoon in the summer. I calculated heat loss rates to determine the amount of glazing I would need. The curving roof and rounded walls give the house a feeling of welcome and familiarity. At night, I can watch the stars and the passage of the moon as I lie in bed.

Growing Pains

After the shop was completed, I found the Trace 2524 was not up to the task of running all my tools efficiently. Other loads interfered with the starting of 1-1/2 horsepower motors. The folks at EV Solar in Chino Valley had a used set of two interfaced 2248 Trace inverters. I put my 2524 up for sale and purchased the 2248s and some more batteries, since I now needed to rewire for 48 volts.

Two years later, with the house livable, I found that the ceiling fans were humming objectionably. And I was not feeling confident about the ability of the 2248s, one of which had gone in for repair. I sold the 2248s and bought a Trace 4048 sine wave inverter, which has exceeded my expectations. The tools and ceiling fans are happy, and so am I.

After several years of use, I added EDTA to the batteries and noticed a slight gain on the hydrometer reading after a month, which has remained for the last two years.

Upgrades & Acquisitions

As time passed, I upgraded the sixteen original panels with eight SP75 panels and two Air 303 wind generators. One wind generator is mounted on the top of the tower of the house that gives access to a rooftop deck, and the other is mounted above the shop.

The two Air 303 wind generators have been operating for two years, and were the very first 48 volt ones produced in Flagstaff. With frequent high wind gusts, I have seen a combined 10 amps produced for a few seconds, but 2 to 4 amps is most common. I suspect that the wind provides less than 10 percent of the energy generated by our system.

My latest addition to the system is two Zomeworks trackers for sixteen Arco M-51s and the eight SP75 panels. My next change will be to replace the eight L-16

Five M-75 Arco panels on the south of the house.

Berney System Costs

Qty.	Item	Cost (US$)
8	Siemens SP75 80 W panels	$3,352
3	Zomeworks trackers	2,900
	Trace 4048 inverter	2,800
16	Arco M-51 32 W panels	2,560
8	Trojan L-16 batteries	1,440
5	Arco M-75 38 W panels	1,275
	Onan 4 KW generator	1,200
2	Air 303 wind generators	930
	Wire, pipe, & miscellaneous	600
	Trace T-220 transformer	265
	Circuit breaker	163
	Trace C-40 charge controller	120
	Class T fuse, 400 amp	38
	Total	$17,643

batteries with sixteen L-16s when the present eight are no longer serviceable. This year I purchased an Onan 4,000 watt generator, which allows me to be a bit less frugal with electricity when I have company.

I have noticed that the old Arco panels benefit greatly from the reflection of sunlight from the snow, delivering 40 percent more power, while the SP75s give their usual constant amperage. The Arco panels deliver the same now as when I first installed them.

These are the panels that feed the batteries at present:

- Sixteen Arco M-51, 32 watts each, producing 8 amps at 48 volts
- Eight SP75, 80 watts each, producing 9 amps at 48 volts
- Five Arco M-75, 38 watts each, producing 3 amps at 48 volts

All the panels are wired for 48 volts and pass through a Trace C-40. The amperage readings given are based on two small ammeters, which may not be very accurate, but the readings are consistent day-to-day.

The panels are now mounted on three trackers, which has made a considerable difference in the energy supply. Previously I had built some temporary wooden supports for the panels that I could seasonally tilt up or down to follow the path of the sun across the sky.

Efficient Appliances

We first chose a highly efficient mass-market refrigerator, attempting to avoid the cost of a Sun Frost. But I was running low on energy nearly every day when I was using it. So we quickly sold that refrigerator and purchased a sixteen-cubic-foot AC Sun Frost, which has exceeded our expectations.

After reading about the Staber washing machine in *Home Power,* we purchased one. We're extremely pleased with its performance and low use of water and energy, both of which are of concern to us.

We put in a Bosch dishwasher, which is very energy efficient, uses much less water than other models, is extremely quiet, and relatively inexpensive. Other appliances we run are a computer and printer, TV for watching movies with a VCR, and several stereos.

Some of our lights are fluorescent and a few are incandescent. The house is designed so that no lights are needed in the day. There are four skylights in the house. We have three ceiling fans. All appliances in the house are AC.

Unlike most off-grid homes, we also cook with electricity, using an induction GE cooktop and a convection oven. Of all the appliances we have, I like the cooktop best. It heats quickly, leaving the cooktop itself cool (except directly underneath the pot, which heats the cooktop by sharing its heat with it).

We use a Trace transformer to provide the 220 volts AC needed for the cooktop. It draws about 15 amps on high. However, it heats so rapidly that it takes very little time to boil water. I never use more than two burners at once.

Ariella standing in the kitchen with the induction cooktop and Sun Frost RF-16.

Berney System Loads

Item	Watts	Average Hrs / day	Average WH / day
Induction cooktop	1,600	1.00	1,600.0
Well pump, DC	250	6.00	1,500.0
Sanders	1,200	1.14	1,371.4
Staber washing machine	800	1.00	800.0
Lights	200	3.00	600.0
Sun Frost RF-16	60	10.00	600.0
Table saw	1,800	0.29	514.3
Convection oven	1,500	0.33	500.0
Planer	1,660	0.29	474.3
Band saw	1,450	0.29	414.3
Vacuum cleaner	1,000	0.33	333.3
Jointer	1,450	0.21	310.7
H_20 conditioner	10	24.00	240.0
Toaster, four-slice	1,800	0.08	150.0
Clock	4	24.00	96.0
TV	80	1.00	80.0
Drills	400	0.14	57.1
Steam cleaner	1,500	0.04	53.6
Computer monitor	100	0.50	50.0
Dishwasher	1,400	0.03	46.7
Cappuccino maker	1,200	0.04	42.9
Heat storage fan	600	0.07	42.9
Iron	1,200	0.03	40.0
VCR	30	1.00	30.0
Lathe	900	0.03	30.0
Computer	55	0.50	27.5
Pressure pump	370	0.07	26.4
Battery chargers	160	0.14	22.9
Stereo	30	0.33	10.0
VitaMix	1,265	0.01	9.0
Ceiling fans	30	0.25	7.5
Drill press	800	0.01	5.7
Air compressor	1,000	0.01	5.6
Printer	35	0.07	2.5
Coffee grinder	100	0.02	2.4
Total average watt-hours per day			10,096.9

I burnt out the heating system on it, which was and still is under warranty. When it happened a second time, I realized that running it when the batteries were low seemed to be the cause. I adjusted the low voltage cutoff on the Trace inverter to a higher value, and have not had the problem again.

With my small battery pack, I cannot run the cooktop for hours on end, though I use it occasionally for up to an hour at a time. In the course of the day, we will use the cooktop six or seven times. Of course, as in any off-grid home, we pace the use of our appliances according to the available energy.

Seven Year Process

It took me seven years to get my permit of occupation from the county and building department. They adopted the national building code a year before I got my building permit. I had to submit formal plans and receive periodic inspections, but the planning and zoning people were very understanding and helpful as I slowly built the buildings.

The folks at EV Solar were helpful in offering advice about choosing the right equipment and proper installation. When something needed repair or service, they were prompt and helpful. I still stop and visit to see what's new and to bounce ideas off them that I read about in *Home Power* and other publications.

The only complaint I have is that here in arid Arizona, what is normally considered "grey" water is considered "black" and must be run into the septic tank. I did plumb the drain lines so that if they ever change that code, I can easily run the grey water onto my garden and plants. I also dug a pond, and run all the water from the roofs and any that collects in front of the house into it. This I use on the garden in the summer.

Most of the time, there are just two of us living here, but for three months recently, there were six of us all living comfortably with the sun. Meanwhile, we eat fresh vegetables and herbs from the greenhouse year-round. And when the temperature outside is either 100 or 10°F (38 or -12°C), and the wind is howling at the same time, I smile thinking of the energy flowing to my batteries and the comfort I am enjoying inside.

Comfort, Beauty, & Energy Efficiency

People who visit are impressed with how comfortable the house feels. I believe that this feeling comes from the lack of chemicals in the house. The floor joists are steel, the cabinets are made from recycled flooring, and the floors are wood and tile. The joy and love that was given to the building of this structure has been retained in the walls.

It is ten years since I started this project and will be another year or two before I finish. In that period of time, the utility company has arrived next door and a telephone line has made its way into our house.

Classes from the local colleges and schools have visited to see how the sun, wind, and human ingenuity can sit lightly on the earth. I hope that what I've done will allow people to see how comfort, beauty, and energy efficiency are available to any who choose to have it now.

Access
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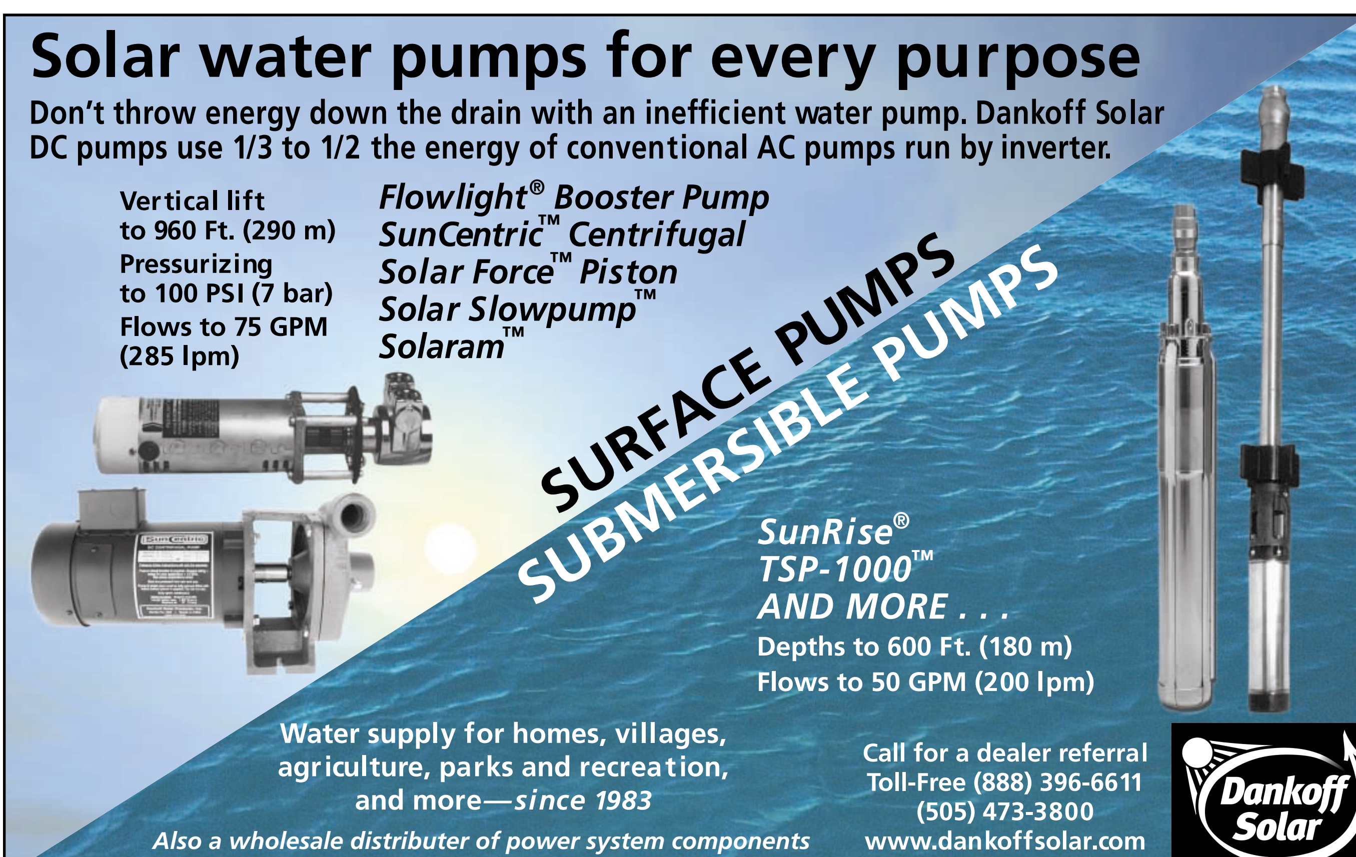

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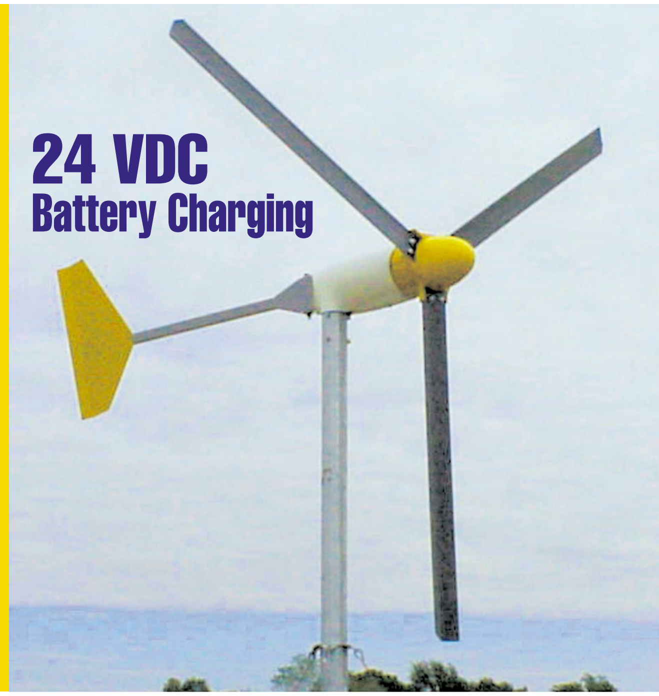

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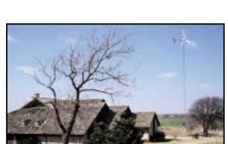

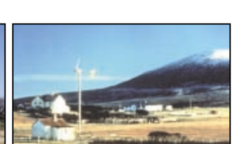

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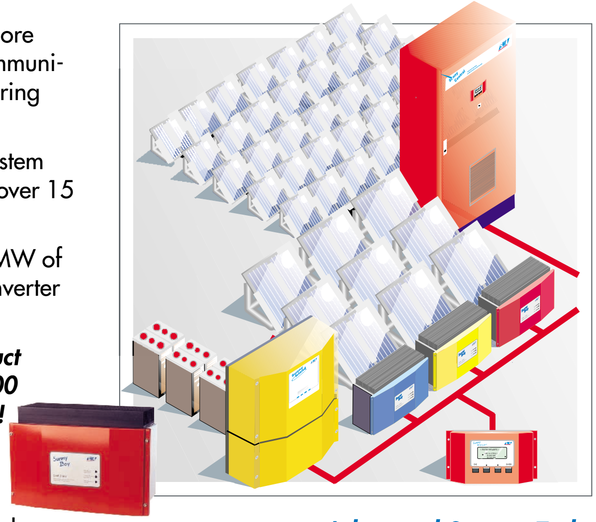

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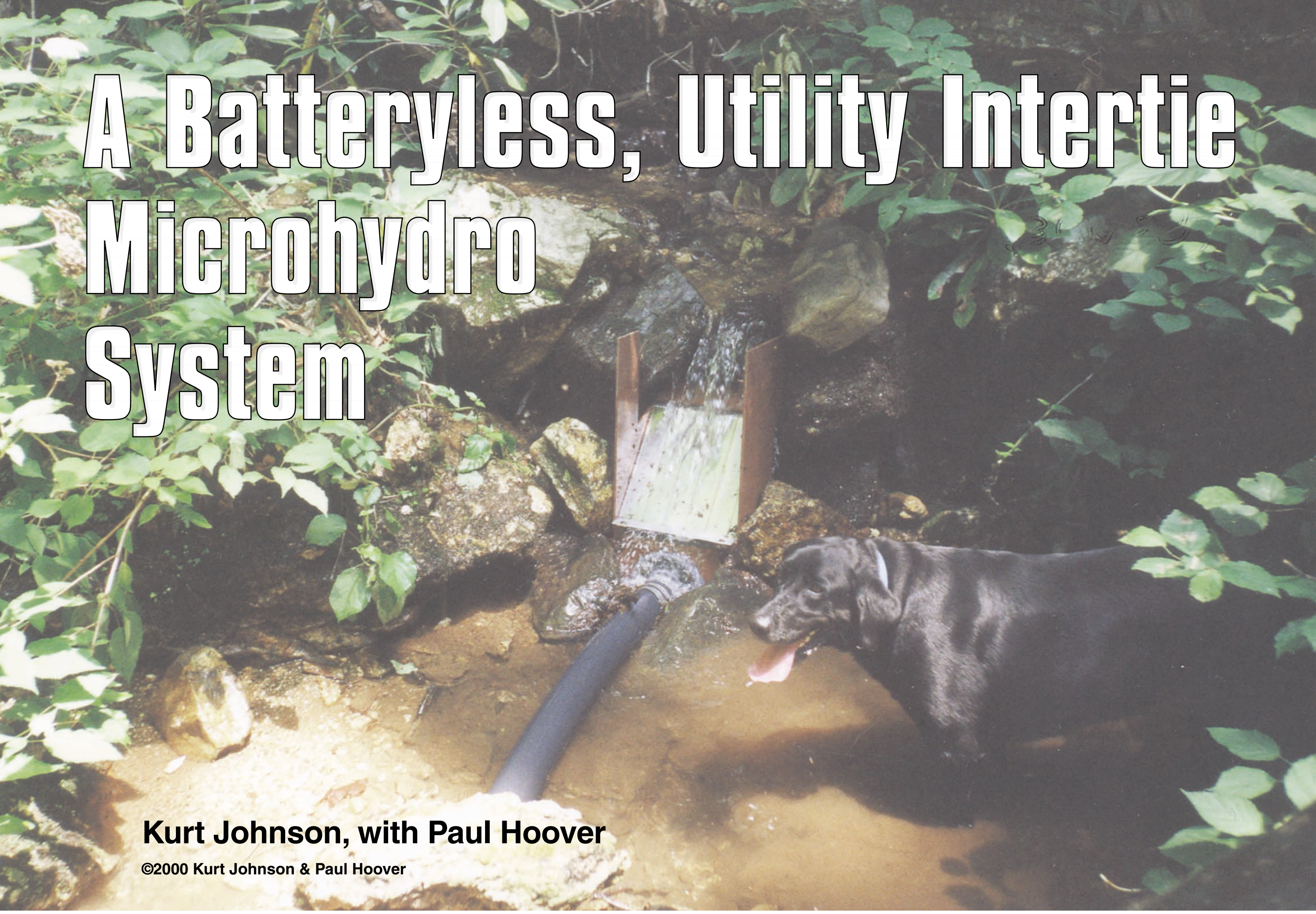

Kurt Johnson, with Paul Hoover

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Sophia likes the Aqua Shear intake—from here, 1,000 feet of pipe runs to the turbine.

Kitty Couch lives near the end of a gravel road outside Burnsville, North Carolina. Plum Branch drops out of a ridge facing the Black Mountains along the east boundary of her property. It is a small, seasonal stream with a flow range of around 60 to 130 gallons per minute. At her location, a 75 foot (23 m) head over a distance of 1,000 feet (305 m) is available.

Kitty is a potter and uses electric kilns. Between her home and shop, she had been using about 650 KWH per month. She wanted to reduce her US$80 monthly electric bill, and wanted to take advantage of the water resource of Plum Branch. She called The Solar Guys, a local renewable energy business that I run, and asked me to design and build a microhydro system for her.

Site Analysis

The site survey started by determining Kitty's property boundaries, and where the stream lay within these boundaries. She had just acquired another 3.5 acres at the upper part of her property, which increased the length of the stream she owned. I took advantage of the fact that the surveyor was coming to map her new boundaries; I met him and got him to show me the highest point of the creek on her property.

From a point within a few feet of the boundary, there was a small waterfall that would work perfectly for the Aqua Shear intake I was hoping to use. After determining the highest possible point on the stream, I needed to determine the lowest. The most obvious place was the existing man-made pond at the bottom end of her property. It already had a 4 inch PVC penstock buried along the stream for about 400 feet (120 m).

This looked like the best place to put the turbine house. All I had to do was tie into the pipe flowing into the pond, and let the tailwater spill into the pond. Next I used a transit and worked my way up the hillside to the small waterfall. I determined that Kitty had 75 feet (23 m) of head for her hydro site. After measuring this out along the proposed path of the penstock, I concluded that adding another 600 feet (180 m) to the existing 400 foot (120 m) penstock would do the job.

Next I needed to determine the flow of the stream. By setting up a small weir to determine the volume, and using a bobber and a stopwatch to determine the speed of the stream, I came up with fairly consistent figures. The stream was yielding 130 gallons per minute (8.2 liters per second) during the wet season.

The neighbor above Kitty's property also has a hydro system on the same stream. Since he is farther up the stream, he has less flow. But he was able to let me know that the stream usually cuts to half its wet season flow during the dry season. From this I figured that the stream would reduce to roughly 60 gallons per minute (3.8 lps) during the dry season.

Now I knew that the head was about 75 feet (23 m), the length of the penstock 1,000 feet (305 m), and the flow of the stream 60 to 130 gpm. I only wanted to use half of that, so I would size the system to use 30 gpm (1.9 lps) in the dry season and 65 gpm (4.1 lps) in the wet season.

Water Intake & Screen

The nice little 18 inch (46 cm) waterfall channeled the stream into a narrow flow of about 6 inches (15 cm) in width. After reading the *HP71* article on the Aqua Shear screen, I had a feeling that this was going to work out well. The screen isn't cheap, at almost US$200 a square foot. But it's worth it to have no maintenance on the intake. Especially since Kitty is in her 70s, and wouldn't want to be continuously cleaning the screen.

When I received the screen, which was the smallest piece I was allowed to order (1 foot by 1 foot; 0.3 x 0.3 m), I made up a mock intake box with plywood. I had to make it so that it conformed to the rocks in the small waterfall and allowed the screen to receive the bulk of the water coming over it.

Then I had to determine where the penstock would attach and how. I also made a little overflow slit above the penstock and below the Aqua Shear screen. This was because we were only taking half the water flowing onto the screen (this was controlled by the size of the orifices at the turbine). The overflow slit helps determine when the orifices need to be changed. When water stops coming out of the overflow, it's time to reduce the size of the orifice.

Once I had perfected this, I took it to a local welder. Fortunately, he had done a lot of work similar to this for the local mining industry over the years. He made a simple 1/4 inch (6 mm) steel plate box from my plywood mockup. It had a footprint that was roughly a square foot (0.09 m^2), with a back wall 18 inches (46 cm) high like that of the waterfall, and a front wall that was determined by the 40 degree pitch of the square foot Aqua Shear screen.

It allowed enough room for the penstock flange to be mounted, and still had room for a 3/4 inch (19 mm) slit for overflow. I later had to put mesh over the slit to keep salamanders from crawling in. The side walls were brought up about 22 inches (56 cm) high to create a channel to force the water toward the screen. On one side, I had to leave a small section out to accommodate a rock.

The stainless steel Aqua Shear screen filters to a 0.5 mm (0.02 inches) particle size, and can draw 350 gallons per minute (22 lps) per square foot (0.09 m^2). It is self cleaning, and should require little or no maintenance.

Penstock

There was already a 4 inch schedule 40 PVC pipe run from the stream to a pond where the turbine now sits on Kitty's property. This pipe had been installed to feed the

A hinged roof covers the two-nozzle Harris turbine. The tailrace dumps into Kitty's pond.

The air release valve between the 600 feet of 3 inch pipe and 400 feet of 4 inch pipe.

man-made pond. The intake for this pipe was some 600 feet (180 m) below the intake needed for the turbine.

I ran a 600 foot section of 3 inch black polyethylene from the turbine intake to the existing PVC pipe. The 4 inch pipe had been buried, and I was able to tie into the top of it with the poly pipe, and run that up through the woods. It ran along the stream, but far enough away to not be affected by flooding.

I was not able to bury the pipe any farther up the stream because of the rough terrain (rock and laurel thickets), so I went with poly pipe. Three inch was sufficient for the water flow, and poly was my choice because of cost, sunlight resistance, freezing durability, and flexibility. I used 100 foot (30 m) lengths of pipe with slip fittings and clamps.

I secured the pipe with metal fenceposts and used stranded galvanized wire with a plastic sheathing to attach the pipe to the posts. In one section, there was an old mining road. I cut a metal culvert in half lengthwise, laid it over the pipe, and buried it. This was to protect it from the frequent 4-wheelers that use the road for recreation.

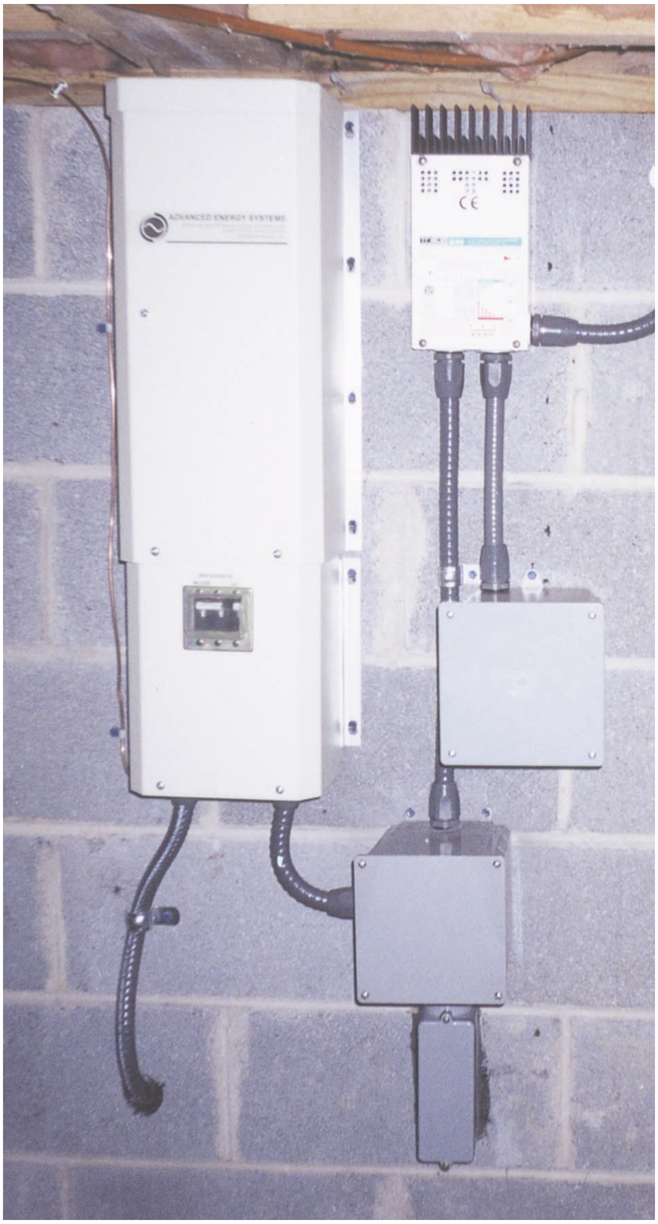
The only other thing noteworthy about the penstock was that where I joined the 3 inch pipe to the 4 inch pipe, I put a breather in so air pockets can be released manually. The outflow from the turbine is directed to the pond.

The turbine is set 2 feet (0.6 m) above the ground level to enable easy changing of nozzles without removing the turbine housing. The turbine house is constructed of concrete block with a hinged roof. There is very little noise, and the turbine is well protected from the elements.

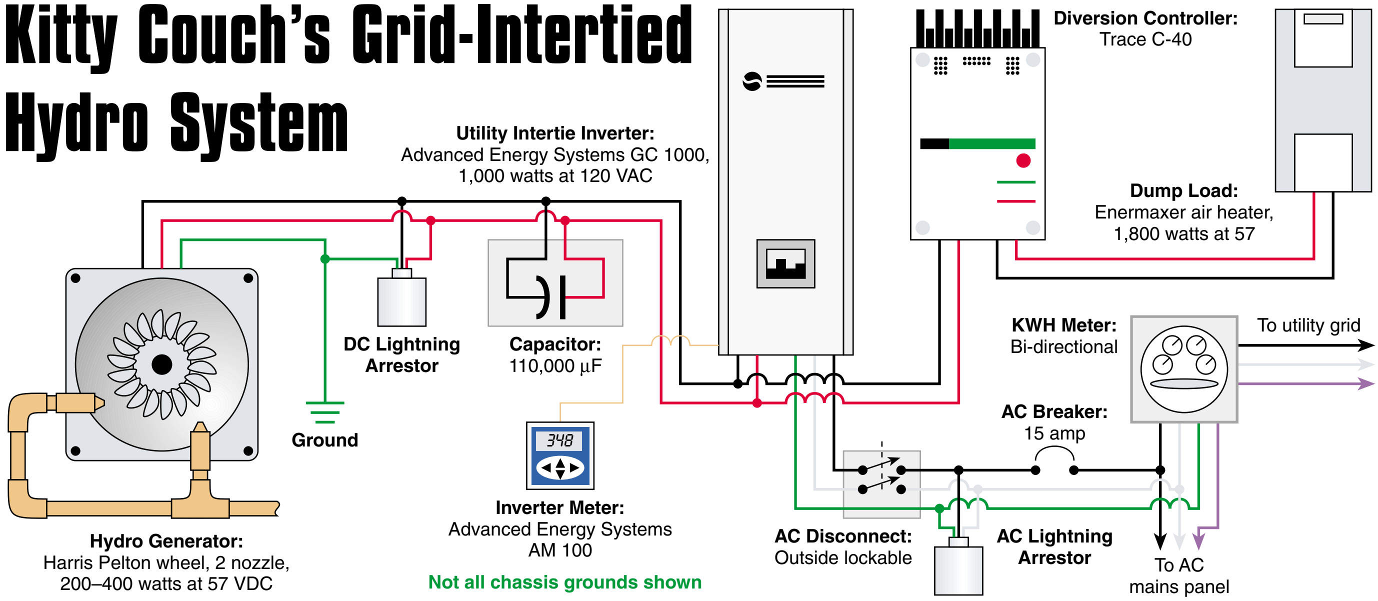
Turbine & Controls

Analysis of Kitty's water resource indicated that the flow and head were adequate for a DC hydro system generating 200 to 400 watts. It would use dual 5/16 inch (8 mm) jets during the dry season for about 200 watts

The Advanced Energy Systems GC1000 intertie inverter and Trace C-40 used as a diversion controller.



Kitty Couch's Grid-Intertied Hydro System



of output. During late fall and winter, up to 400 watts could be generated using dual 7/16 inch (11 mm) jets. The projected flow rates were 30 to 65 gallons per minute (1.9–4.1 lps), or about half the stream flow.

The system would generate 5 to 10 KWH per day or 150 to 300 KWH per month. A 48 volt turbine from Harris Hydroelectric Systems was chosen. It is designed for battery charging of systems up to 48 volts, and can generate up to 1,500 watts. Don Harris told me that 57 volts is the optimum voltage for this unit. In Kitty's system, the controller will not allow the voltage to go over 60 volts maximum.

Kitty needed the grid to meet her average and peak electric needs, and she was not interested in a backup power system. So she decided to go with an intertie system without batteries. This presented several opportunities and challenges. She would not need battery charging capacity in her system, or a charge controller. There is no need to limit DC output voltage to that of the battery bank for this sort of system.

Using the grid as the load and in place of a battery bank also means saving the cost of batteries and having to maintain them. These factors led to choosing an inverter that did not have battery charging capability and which would accept a higher DC input voltage. This reduced the wire size needed between the turbine and the house, where the inverter was to be installed. This distance is about 225 feet (70 m), and #2 (34 mm^2) copper wire is sufficient to keep losses below 2 percent.

The system design is shown in the schematic. The Advanced Energy Systems GC 1000 used in this system is a 1 KW inverter designed for interfacing fuel cells with the grid. It does not have power point tracking, which the standard GC 1000 designed for PVs does have. It will accept DC input voltages from 45 to 75 volts.

The inverter and microhydro generator are coupled so that the inverter controls the generator output voltage at 57 volts. Turbine alternator output is regulated via parallel shunt regulation. The inverter output is 120 volts, 60 cycle synchronized with the grid, and the GC 1000 has all the disconnect features required for interconnection with the grid.

The system needed a dump load in case grid power failed, shutting down the inverter, or if the inverter itself shut down. Without a constant load, the turbine will overspeed and be damaged. I chose the Enermaxer

Couch Hydro System Costs

Item	*Cost (US$)*
AES GC 1000 inverter, GFI, & disconnect	$1,785
Harris Hydroelectric turbine, 2 nozzle, 48 V	1,360
Penstock & pipe fittings	1,000
Wire, conduit, & miscellaneous electrical	600
AES AM 100 inverter monitor	540
Turbine house & penstock hardware	500
Steel intake pieces	200
Trace C-40	195
Aqua Shear intake screen	185
Enermaxer air diversion load, 48 V	175
Electrolytic capacitor	56
Total	$6,596

1,800 watt, 48 volt (30 amps at 60 volts) air heater for a diversion load because it met the specs of the system. I felt that putting in a water heater for diversion was more trouble than it was worth because the system will rarely go down.

Smoothing It Out

Batteries in a microhydro system are like a flywheel, and serve to smooth out voltage fluctuations. A controller such as the Trace C-40 can be used as a load controller, and can switch to a dump load when voltage increases above a set level. In this application, the C-40 is set in charge control mode to dump power when the voltage rises above 60 volts. However, the control function is not reliable if voltage fluctuates.

When initially installed, the C-40 load controller was set to switch to the dump load at 60 volts. However, during tests it would sometimes switch even when there was no loss of power or inverter output. Worse yet, it would fail to trip when the inverter was shut down. The challenge was to smooth voltage fluctuations.

A high capacity (110,000 microfarad) electrolytic capacitor was double-lugged with the leads from the hydro turbine across the battery input terminals of the C-40. The PV input terminals on the C-40 are connected to the dump load. The C-40 now properly senses the voltage and switches to the dump load within a fraction of a second whenever the DC voltage exceeds 60 volts. In this way, it protects the turbine from overspeeding.

My thanks to Mark McCray of RMS Electric, Dean VanVleet of Trace Engineering, Ed Hall and Chris Badger at AES, Don Harris of Harris Hydro, and Derek Veenhuis and Dennis Ledbetter of APC for their help in figuring out how to handle the dump load diversion.

Net Metering

North Carolina does not have net metering legislation. But the French Broad Electric Membership Corp. (“French Broad” refers to a river in the area), which serves Western counties in NC, supports distributed renewable energy systems and allows net metering. They are more than willing to let their customers sell power back to the grid. They require that customers don’t produce more power than they use, have a lockable disconnect on the system accessible by the utility company, and use inverters in their systems that are proven to not backfeed the grid in times of power outages (such as Trace and AES).

They also require that you pull a permit and get an electrical inspection and an inspection by French Broad. And last but not least, they have you pay your utility bill once a year instead of once a month. So if you

Kurt and Kitty—proud and powered.

are out of town for a month and make more than you use, it won’t confuse the meter reader into thinking that your meter turned over a full 100,000 KWH instead of just spinning backwards a few KWH. In the event that you do make more than you use in a year, they will charge you a US$50 processing fee. If there is still any more owed, they will write the customer a check.

I used a local electrician, Danny Honeycutt, to pull the permit and wire the AC side of the system to meet code and the grid-tie requirements. Danny also proved to be extremely valuable in helping me fine tune the running of the system. We established a great working relationship on this project, and now work together on every install I do, whether it be grid-tie, stand-alone, PV, wind, or hydro. We now can also offer to wire the complete house, which the customer tends to like.

Up & Running

Kitty’s system became operational at the end of May, 2000. Charles Tolley, General Manager of French Broad, came to the site to inspect and approve the system. He was pleased that the system was installed according to code, and pulled the meter himself to see that the system posed no danger to his linemen during power outages.

An Advanced Energy AM 100 inverter monitor was also installed. It logs all inverter operating data. Data is averaged over 15 minute intervals, and stored for up to the last twenty days. It also maintains an event log with data on startup and stops, grid power failures, and the like. The system is generating 4.9 KWH per day in the dry season. Earlier, at the end of the wet season, the measured output was about 10 KWH per day.

Responsible for Our Energy Use

Kitty has had an interest in doing this for many years. She loves nature, and lives right in the heart of it. Over the years, she has noticed the impact that pollution has had on the local environment. This is especially evident when you go to the top of Mount Mitchell and see the damage that acid rain has done to the vegetation on the mountain.

Kitty realizes that she is a part of the reason this acid rain is here. She drives a car, and uses electricity that is predominantly produced by coal (one of the main contributions to the pollution in North Carolina, which is only third to California and Texas in pollution production). Kitty wanted to do her part to fix that.

She realized that she only had a small stream, and that her power production would be minor, but it was still important to her. Of course cost was an issue, so figuring out how to grid-tie the system without a battery bank was a key factor in making this project affordable.

The savings on her power bill has been moderate, but not insignificant. During the wet season, the turbine cuts almost US$30 off Kitty's bill (300 KWH times 9.5 cents per KWH), and during the dry season it is doing about half that. She now gets a kick out of looking at her meter. She can see how much power she is producing, and feel good that it is coming from a renewable source, and not from burning coal.

Access

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Paul Hoover • 828-675-5393 • Avocet365@aol.com

Clara "Kitty" Couch, Rt. 8 Box 915, Burnsville, NC 28714 • 828-675-5608 • ckcouch@ioa.com
System owner

Danny Honeycutt, IFIWASYOU Construction, PO Box 36, Bakersville, NC 28705 • Phone/Fax: 828-675-9144
Electrician

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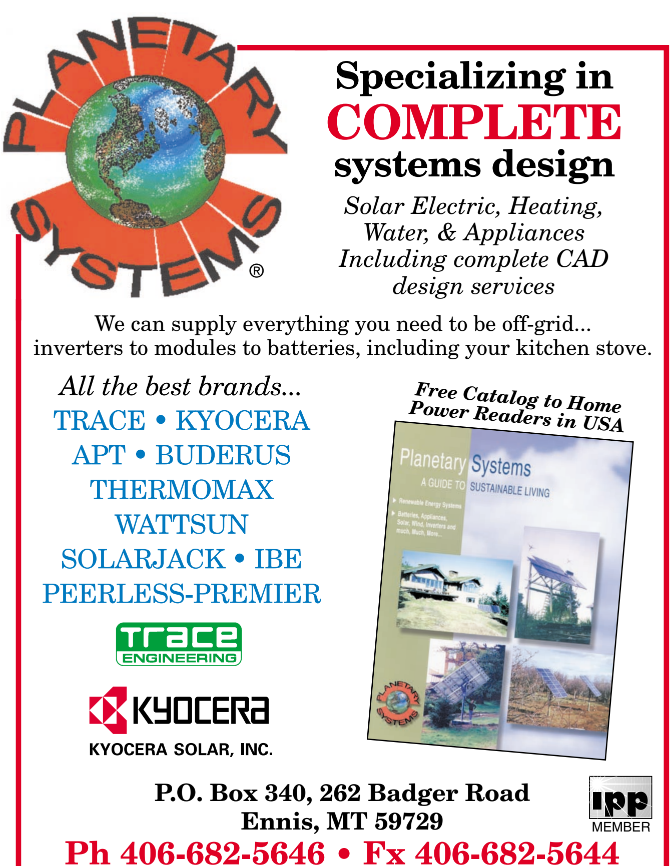

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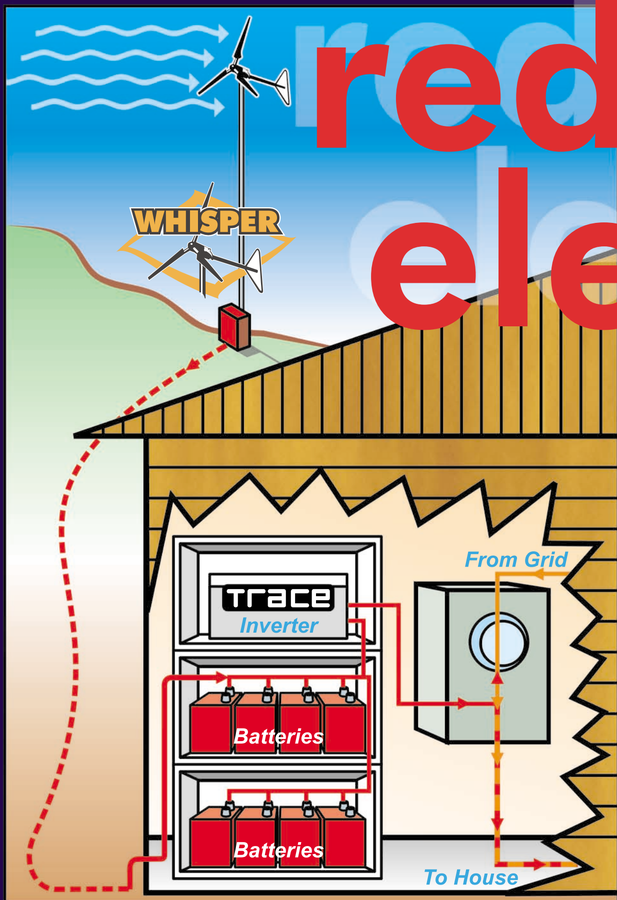

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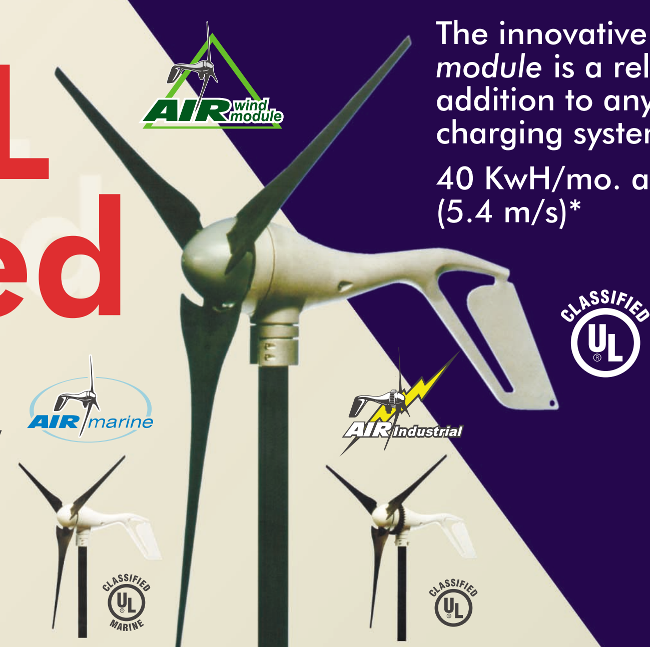
40 KwH/mo. at 12 mph (5.4 m/s)*



Southwest Windpower is proud to announce that Models Air 403 Land, Marine and Industrial Wind Turbine Generating Systems now comply with all safety and design requirements as outlined in IEC 61400-2 and have earned the right to bear the Underwriters Laboratories Inc. (UL) Classification Mark. For more information on UL, its services, or UL product certification, visit their Web site at www.ul.com.

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PV payback

Karl E. Knapp & Theresa L. Jester

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Critics of solar energy have been known to claim that it takes more energy to produce photovoltaic (PV) modules than the modules will produce in their lifetime. We've conducted a detailed and scientific empirical study to look into this question. We found that the skeptics' assertions are false. PVs recoup their production energy in two to four years, and go on to produce clean, renewable energy for twenty to thirty years or more!

Our study examined energy costs for two types of Siemens PV modules—single-crystalline silicon (SC-Si) and thin film copper indium diselenide (CIS). Crystalline silicon modules achieve an energy break-even in a little over three years. The energy payback time for thin film copper indium diselenide modules in full production is just under two years. Over their lifetime, these solar panels generate nine to seventeen times the energy required to produce them.

Real Costs

Our research was based on direct investigation of the energy requirements and net energy production of manufactured photovoltaic modules. Other studies employ production models with assumed process recipes, equipment sets, materials yields, and module efficiencies. None of them have used actual utility bills and accounting records.

By contrast, our study didn't have to make any assumptions about yields. We just took energy requirements right off the utility bills and the materials requirements right off the bill of materials. This allowed us to include indirect materials as well, which as far as we can tell have never been included before. These include things like argon, nitrogen, etchants, cleaners, and so forth, all the way down to the cardboard box the modules get shipped in.

Energy Payback Time

Energy payback time is one standard of measurement adopted by several analysts to look at the energy sustainability of various technologies. It is defined as the time necessary for a photovoltaic panel to generate the amount of energy used to produce it.

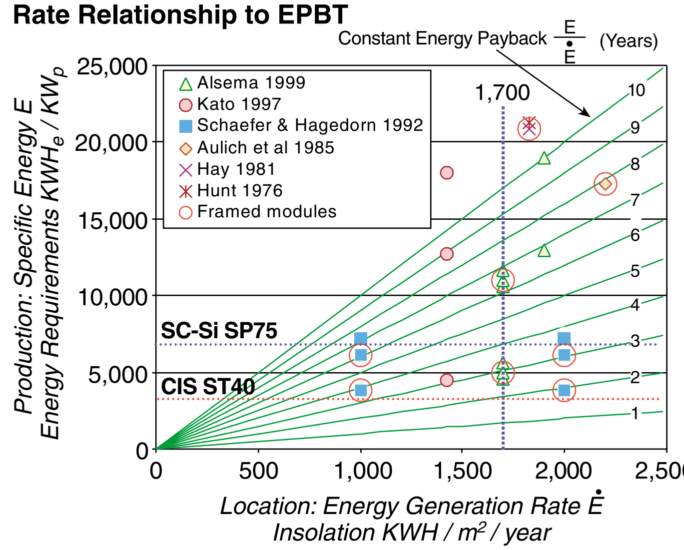
Two parameters determine the energy payback time for a PV module—how it is produced and how it is used. The energy needed to produce a product (specific energy) includes both the energy consumed directly by the manufacturer during processing, and the energy embodied in the incoming raw materials.

How a PV module is used is primarily a question of location and module efficiencey. Location determines the solar insolation, and combined with efficiency, determines the electrical output of the PV panel. But installation details are important too (fixed tilt or tracking, grid-connected or stand-alone, etc.), as are balance of system requirements such as mounting structure, inverter, and batteries. The module energy payback time is computed from this formula:

$$\text{EPBT} = \frac{\textbf{Specific Energy}}{\textbf{Energy Generation Rate}} = \frac{E}{\dot{E}}$$

Figure 1 shows this relationship. The vertical axis shows specific energy and the horizontal axis shows the energy generation rate (with some representative estimates found in the literature indicated). Energy payback time can be expressed as the ratio of the total energy required to manufacture a photovoltaic module to the rate that the module converts the solar energy flowing from the sun at the installation site to electricity.

Figure 1: Specific Energy and Energy Generation Rate Relationship to EPBT



Japan:1,424; Northern Europe: 1,000; U.S. Avg: 1,825; Boulder: 1,974; Phoenix 2,480; Detroit: 1,202

Lines of constant energy payback are indicated in Figure 1 by the diagonal lines. A sunnier location (a move to the right), or lower energy requirements or higher module efficiency (a move downward), reduces the payback time.

Previous Research

Several reported results for a variety of technologies, system types, and installation locations and styles are indicated in Figure 1. The analyses range from solar cells to full systems. Circled datapoints correspond to framed modules, the emphasis in this analysis. Results from our research are indicated by horizontal dotted lines.

Published results from several excellent studies of PV energy requirements vary considerably. Some of this is due to different energy findings, and some to different insolation assumptions. These variations are made a little more clear by plotting them together on this chart.

Some analyses assume the use of frameless modules. These have lower energy requirements than the more standard aluminum frames (indicated by circled datapoints), because aluminum requires a lot of energy to produce. Both SSI products studied include aluminum frames.

One of the key contributors to the energy payback field is Eric Alsema, whose work is recent, comprehensive, and clear on methodology and data. Alsema's module payback estimates for current SC-Si technology range from a low of 2.9 to a high of 6.5 years (at 1,700 KWH/m^2/year).

Methodology & Assumptions

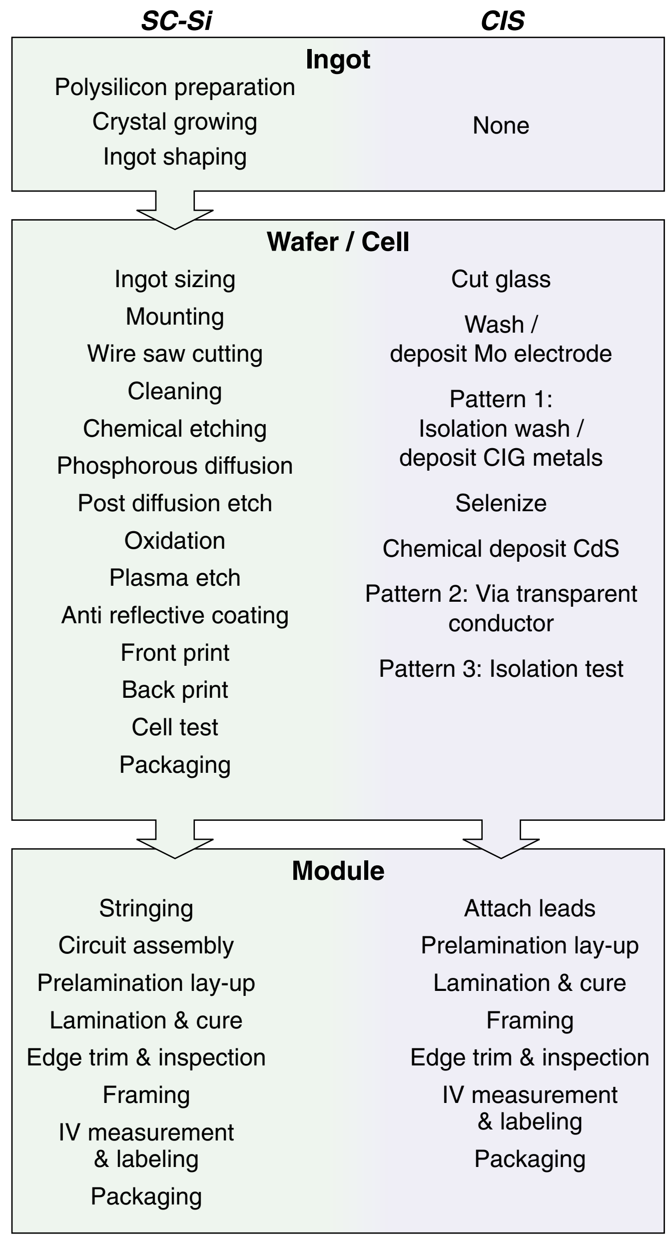
This investigation deviates from and complements earlier research. Ours was primarily an empirical endeavor. We used measured energy use, actual utility bills, production data, and complete bills of materials to determine process energy and fully yielded (total input) raw materials requirements.

The materials include direct materials that are part of the finished product, such as silicon, glass, and aluminum. They also include indirect materials that are used in the process but do not end up in the product, such as solvents, argon, or cutting wire. Many of these indirect materials turn out to be significant. We combined the best available estimate for embodied energy content for each material with records of materials use. This gave us the total embodied and process energy requirements for each major step of the process.

Energy Content

There are three basic steps in producing a crystalline silicon PV module:

Figure 2: Manufacturing Process Sequence



- Growth of the silicon crystalline ingot.
- Slicing the ingot into wafers and processing into solar cells.
- Interconnecting the cells into circuits, laminating to glass, and completing the assembly of a framed and packaged module.

CIS modules require fewer steps. Their complete circuits are fabricated directly as a coating on a glass substrate. The process steps for both technologies are illustrated in Figure 2.

The energy content of raw materials and direct process energy used at the Siemens Solar facility are included

in the analysis. Excluded from the analysis are energy embodied in the equipment and the facility itself, energy needed to transport goods to and from the facility, energy used by employees in commuting to work, and decommissioning and disposal or other end-of-life energy requirements. These are all very minor factors in the total energy picture of PVs.

The energy requirements for incoming silicon includes the energy used to produce metallurgical grade silicon and refine it to polysilicon. This is consistent with most other published PV energy studies.

All energy forms are converted to their electrical energy equivalents, expressed in kilowatt-hours electric (KWH_e). For natural gas and thermal energy, a conversion efficiency of 35 percent was assumed. Energy and materials requirements were tallied on a per-module basis for two representative products: the 75 watt SP75 (SC-Si) and the 38 watt ST40 (CIS).

Conversions to area (m^2) and module rated peak power (KW_p) basis are easily computed from module area and power rating from the product datasheets. The resulting specific energy requirements are expressed in KWH_e/KW_p.

This choice of units is convenient and intuitive because it represents something physical—the number of full-sun hours required for energy payback. To convert to actual days or years, just divide by the average solar insolation, usually expressed in KWH/m^2/year. Then correct for any performance changes from the rating due to system losses or module operating temperature (which was not included in this analysis because it is site-specific).

The U.S. average solar insolation is 1,825 KWH/m^2/year (five full-sun hours per day). A common mid-range number used in the literature is 1,700 KWH/m^2/year (4.7 full-sun hours per day), which is more typical of Europe.

Energy Use

The process energy was derived from utility bills and monthly production data. From October 1998 through March 1999, Siemens Solar Industries (SSI) consumed a total of 20 million KWH of electricity and about 90,000 therms of natural gas. During this time, SSI produced 3 kilometers of silicon ingot (about 111 tons of incoming

Figure 3a: Materials Energy Content: SP75

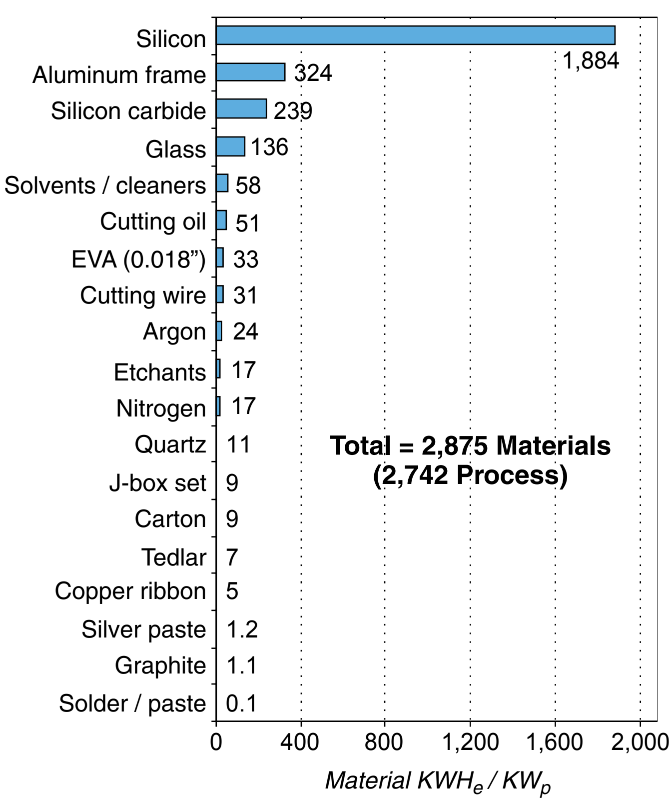
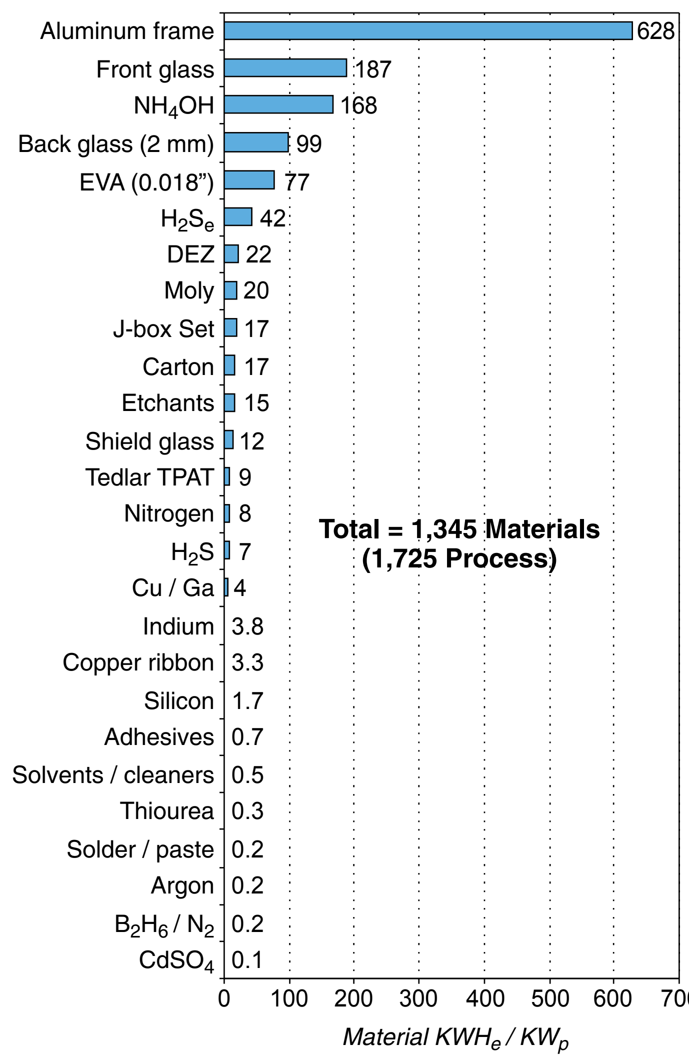


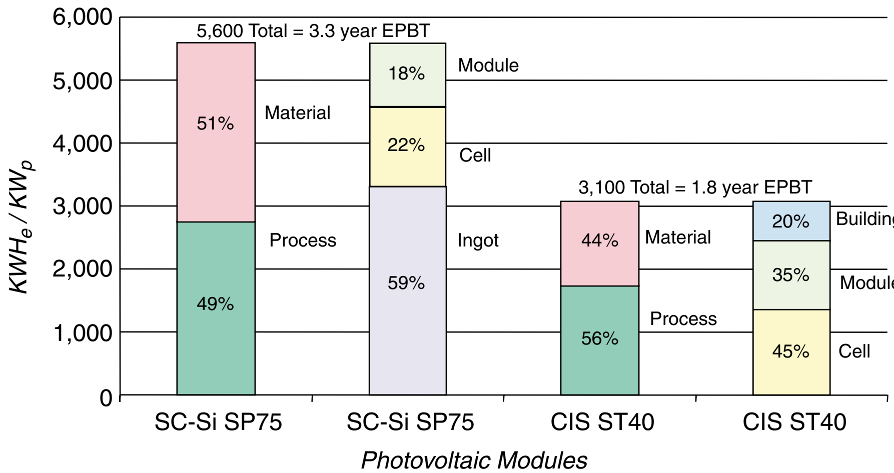
Figure 3b: Materials Energy Content: ST40



silicon), 9 MW of solar cells (about 5 million cells), and 6 MW of modules at its Vancouver and Camarillo sites.

CIS is in the early stages of production scale-up, and therefore energy requirements were estimated using empirical data applied at full production rates. Measured energy consumption along with equipment ratings from nameplates, manufacturers' specifications, or connected circuit breaker ratings were used in conjunction with the equipment duty cycle for all pieces of equipment to derive the process energy use estimates.

Figure 4: Energy Requirements Breakdown



EPBT computed at 1,700 KWH / m² / year.

Total raw materials requirements and the resulting embodied energy contribution are based on production bills of materials and the amount of energy needed to create the incoming materials (derived from existing literature and materials manufacturers). Materials are shown in decreasing order of their embodied energy contribution in Figure 3. The total materials energy contribution for production modules is not far from the process energy requirement: 2,857 KWH_e/KW_p for SC-Si (about 85% due to direct materials) and 1,345 for CIS (97% direct).

The gross energy requirement is the sum of the process and embodied materials energy. These are summarized by category and process step in Figure 4 and Table 1. Payback time is computed as the ratio of the gross energy requirement to the solar insolation at the installation site. A typical value of 1,700 KWH/m²/year yields 3.3 years for silicon and 1.8 years for production CIS.

System losses due to wires, inverters, cell operating temperatures, and so forth can be used as a direct multiplier for the specific location. For a typical generation rate adjustment of about 0.80, the payback time jumps to about 4.1, and 2.2 years, respectively. The final computations are similar to the most recent and thorough published results, obtained using very different methods.

Energy Requirements Breakdown by Energy Source Category & Process Step

SC-Si

	KWH_e / KW_p				EPBT*
	Ingot	*Cell*	*Module*	*Total*	*(years)*
Process	1,380	850	510	2,740	1.6
Indirect material	35	415	-	450	0.3
Direct material	1,885	-	525	2,410	1.4
Total	3,300	1,265	1,035	5,600	3.3
EPBT (yrs)*	1.9	0.7	0.6	3.3	

CIS ST40

	KWH_e / KW_p				EPBT*
	Cell	*Module*	*Other*	*Total*	*(years)*
Process	960	145	620	1,725	1.0
Indirect material	35	-	-	35	0.0
Direct material	370	940	-	1,310	0.8
Total	1,365	1,085	620	3,070	1.8
EPBT (yrs)*	0.8	0.6	0.4	1.8	

* Energy payback time, calculated at 1,700 KWH / m² / year insolation.
Some totals do not add up due to rounding.

Acknowledgments
The authors thank Gernot Oswald and Chet Farris in particular for the opportunity to undertake this research. Kudos are due to SSI's Marie Drape, Maria Tsimanis, and Robert Gay. Thanks also to NREL's Ken Zweibel and David Kline, who helped jump-start the research, and to Eric Alsema, who provided timely information that dramatically improved the analysis.

The Real Renewable Payback
Our study and analysis indicates that payback times for today's SC-Si and CIS photovoltaic technologies are substantially less than their expected lifetimes. With a module lifetime of thirty years, an SP75 will produce nine times the energy used in its production and an ST40 seventeen times.

The effects of the other components of a photovoltaic system can be significant compared to the module payoff, most notably in systems requiring batteries. You have to take into account all components of a PV system. The whole system needs to be a net gain to be truly sustainable.

Access

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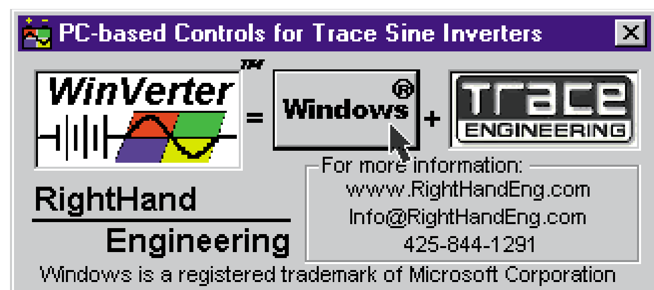


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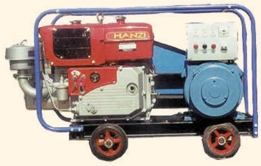

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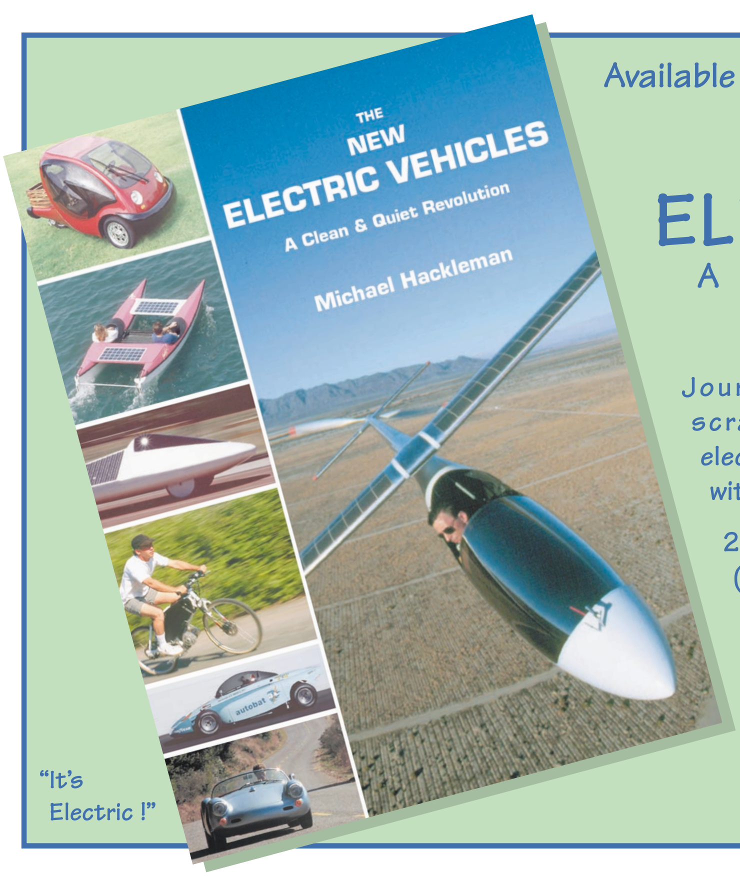

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Trying a Small System First

Rudy & Jill Ruterbusch

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For several years we have lived in a small log cabin on our high bluff property near Frankfort, Michigan. We have marveled at the plentiful sun, breezy afternoons, and relentless surf that our corner of the Great Lakes offers. All the while, we imported our electrical power over a long thin wire, and wondered if there was some way to harness the energy around us.

After reading *Home Power* for a year, doing some research, and looking at a few boat and RV systems, we learned that it's possible. The problem was finding a way to measure just how much wind and sun we had. We considered putting up some measuring instruments, and then spending a year compiling data. For about US$1,000 you can put up a nice system that records data onto your computer.

We already had the power company keeping good records on our loads. If we had similar information on our available source, it would be simple math to design a system to produce our own electricity.

Then we thought of a better idea—take the $1,000 and build a small wind and solar-electric system instead. This way, we would have hands-on experience, a reliable backup power system for small loads, and already be producing some of our own power.

System Design

What was needed was a small wind plant, a small solar array, some batteries, meters, and DC loads we could use when power was available. We attended the Midwest Renewable Energy Fair in 1997, went to several workshops, and purchased most of our equipment right on the spot.

We selected the Southwest Windpower Air 303 because of its simplicity, size, and price. With its internal regulator, light weight, and two-wire DC output, it is a plant we felt capable of installing ourselves.

Next we selected the Solarex VLX-53 panel because of its size, cost, and appearance. While not mentioned in many articles, we thought it was important to select solar components that didn't detract from the natural beauty of our home and property.

We purchased four Trojan T-105 batteries for our energy storage. They were easy to find at a local golf cart repair business for US$52 each. The company also makes custom cables with #6 (13 mm^2) USE wire and soldered connectors very inexpensively.

Then after consulting with our local electrical inspector, we made up some wiring diagrams, applied for a permit, and purchased Square D breakers, boxes, and disconnects. Our inspector was very helpful, steering us away from possible problems before we laid the first piece of wire.

Installation

Our goal during the entire project was to stay as low-tech as possible. For the tower, we cut down a tall skinny tree in the woods. We erected it between two shorter, heavier poles that were cemented into the ground, much like an old flagpole. Using two large bolts, one became the hinge point for tilting the tower up and down, and the other held it in place while the guy lines were secured.

This temporary pole tower is 45 feet (14 m) tall. None of the obstructions (trees, cabin, etc.) extend above about 25 feet (8 m). Our cabin is on a little hill with falling terrain in three directions. It was a good spot for the wind generator, except for the noise. We've found a better permanent spot for a larger wind generator since then.

The tower wiring simply ran through a plastic conduit that was attached to the side of the pole, with a flexible section at the bottom to allow the tower to tilt up and down without disconnecting anything. Wires ran underground to the cabin from there.

The solar panel was mounted on a home-built rack made from 1-1/4 inch (3 cm) aluminum angle and some stainless hardware. The rack was built to hold two additional panels, which were added about a year later. It was attached to the porch roof on the south side of the cabin. It has adjustable rear legs to allow for summer and winter tilt settings. The wind tower top, solar rack, and main DC box were each earth grounded using separate ground rods and wires.

Our battery box was constructed of scrap plywood, with a hinged top for periodic inspection, and a removable front wall to make battery maintenance easier. The box is vented outside with a 3 inch (7.6 cm) flexible tube on one end. Air from the crawl space is allowed to enter the other end through a small screened opening. We also added Hydrocaps to all four batteries. So far, we have only added water once in over a year.

Once the battery box was installed, we ran a 30 amp service up to a six-circuit panel in the kitchen and connected some DC loads to the box. The low voltage under-cabinet lighting in the kitchen was simply rewired to the 12 volt box. We also wired in a radio, a fan, and a couple of small lamps with new cord ends and low voltage light bulbs.

Our system received final inspection and approval in the spring of 1998. All we needed was some wind and sun, and we didn't have to wait long.

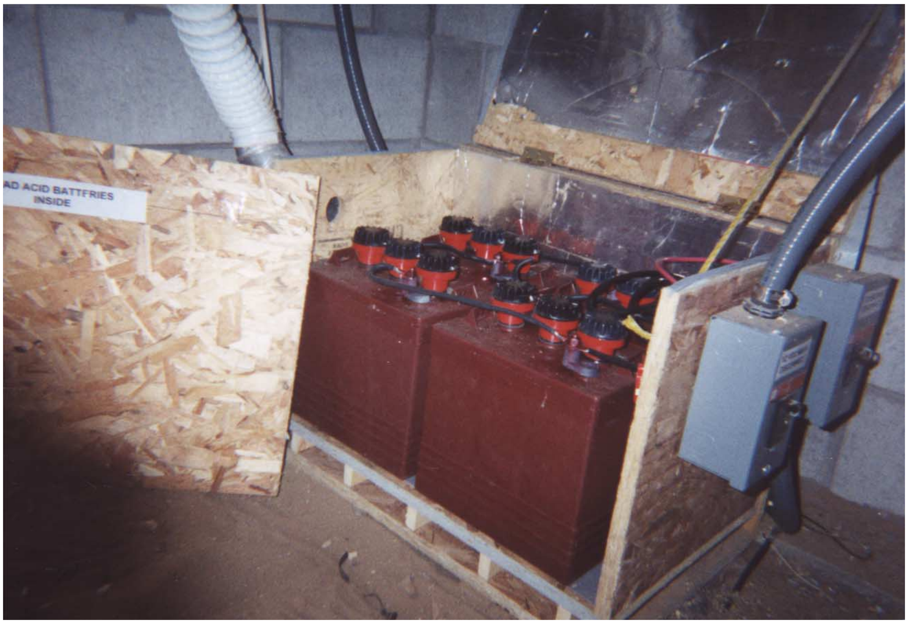
Charge Controlling

After reading *The Complete Battery Book* by Richard Perez, we decided that the solar array could operate unregulated. As long as we limited its size to three panels maximum, the highest charge current would be about 9 amps, and with a fixed rack, that should only occur for three to four hours per day.

Our 440 amp-hour battery bank would never receive more than a C-50 charge rate after reaching full capacity. It would operate as a long, slow equalization during periods of high sun if we were away.

A small diode was installed at the disconnect box on the back of the solar array for each panel input to prevent nighttime discharging. I've checked the Hydrocaps on sunny days after returning home. You can hear them

Four Trojan T-105 batteries, 440 AH at 12 VDC. Note the Hydrocaps, DC disconnects, and removable front wall on the box.



Ruterbusch System Loads

Item	*Watts*	*Hours / day*	*WH / day*
Kitchen light	60	5.0	300
Night light	12	10.0	120
Living room light	25	2.0	50
Radio	8	4.0	32
Bedroom lamp	50	0.5	25
Hall lamp	18	1.0	18
Porch light	25	0.5	12
Fan	10	1.0	10
Bathroom light	20	0.5	10
VCR tape rewinder	40	0.1	4
		Total WH per day	581

working, but they never get more than slightly warm. And the batteries never seem to get above 15 volts during these times.

Low-Tech Data Logging

Since the original idea was to measure our wind and sun, we needed to devise a plan to get the most information out of our low-tech instruments. Our data logger consisted of three ammeters, a voltmeter, a clock, and a notebook. Basically, any time the batteries were estimated to be in the upper third of their charge capacity, we used our DC loads at will.

Then whenever one of us walked through the kitchen, we picked up the notebook and wrote down the date, time, wind amps, solar amps, load amps, and volts. At the end of each week, we could interpolate our approximate watt-hours used, and add it to our annual running total. Occasionally during days of high winds and little sun, we would intentionally run all of our DC loads to extract all that was available from the wind plant, and take frequent readings.

We kept our log sheet next to the meters, and the load amp meter was read between five and thirty times each day. All the loads (except for the light we run all night in the kitchen) are only on when we are in the room using them. There are no phantom loads in our little system—it is all DC.

If we are gone for several days or more, all loads in the system are off. We didn't use these days for analysis, since there were no loads to balance against the charging available.

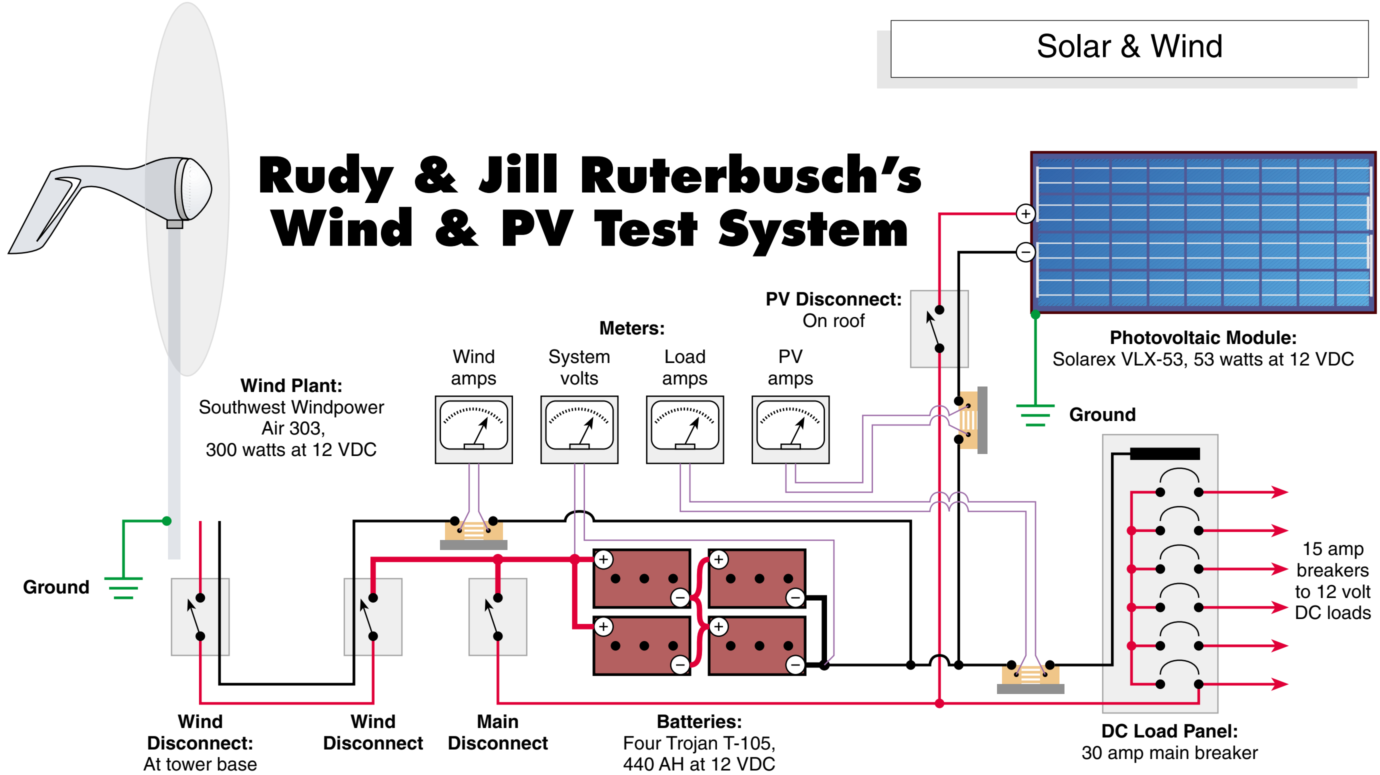
By comparing our data with wind reports from the local Coast Guard station hour by hour, we had a fairly accurate idea of what wind power was actually available. We could now take annual wind data from the National Weather Service and convert it into rough KWH of DC wind power.

The solar panel was much easier to estimate, since it followed a nearly identical curve any day the sun shined. We just had to keep track of rough hours of sunlight each day to compute solar energy available. It was all actually a lot of fun, and provided hours of discussion among our friends, neighbors, and family.

Ruterbusch System Costs

Qty.	*Item*	*Cost (US$)*
1	Air 303 wind generator	$500
1	Solarex VLX-53 module	265
4	Trojan T-105 batteries	208
	Miscellaneous wire and hardware	100
12	Hydrocaps	72
4	Square D DC disconnects	72
1	Home-built PV rack	45
6	Square D breakers	36
1	Square D 6-circuit panel	25
	Total	$1,323

Square D breaker panel with six circuits, DC meters, and wall switch for the 12 VDC light above. Box covers are removed for final inspection.



Results

Our data collection method is obviously not as accurate as actual data logging equipment, but it is fairly close. For about the same amount we would have spent on a data logging system, we are actually producing energy we can use now.

After collecting data for 18 months, expanding our solar array to 150 watts, adding additional DC loads, and watching our batteries very closely, we know we can rely on our little system to provide between 1/2 and 1 KWH each day. This is enough to run all the lighting on our main floor.

We have rarely cycled the batteries below 50 percent state of charge. On one occasion during a week-long family reunion, we had to connect a small battery charger to the batteries to compensate for high demand and low wind and sun. I liken it to running the generator for a day.

We have also learned that the wind at our site during the fall and winter is too much for our little Air wind plant. During storms, I have personally watched our little 300 watt whiz kid produce over 1-1/2 times its rated output for extended periods. It can only handle this abuse for several months before the regulator burns up. We have burned up several regulators in two years trying to make use of this natural power source.

The only two options appear to be upgrading to a stronger unit, or simply turning the Air off during inclement weather or while we are away. Our machine is currently in Flagstaff being upgraded to a model 403 for future use. The Solarex modules have performed flawlessly, and our batteries are holding up fine.

Where We're Going from Here

With the information we now have, we have designed a system that should produce 120 percent of our total power needs. It will consist of a Whisper H-900 wind generator, a 1.2 KW solar array, and 50 KWH of lead-acid batteries. A Trace SW4024 will convert our power to AC. Last fall we applied and were approved for a wind energy grant from the state of Michigan. It will pay for about one quarter of the cost of our wind and battery system.

Two local dealers, John Heiss of Northwoods Energy, and Steve Smiley of Bay Energy Services, Inc., will be participating in our installation. We hope to have the wind system up and running by the fall of 2000. The solar array will be added the following spring. At the moment, a grid intertie is not planned, but we may do that in the future.

Since we do have grid power, we will simply use it in place of a generator for any power shortcomings, or for the occasional equalization. The small amount of money we pay to maintain grid power is acceptable to us under the circumstances. It's actually less expensive than purchasing and maintaining a gas or diesel generator.

Successful Test

In the end, we much prefer building a small system from scratch to going cold turkey into a large one. It was fun, we learned a great deal, and it didn't cost any

Jill and Rudy, ready for a larger system.

more than we would have spent on a data logging system. It provided us with backup power during power outages, and we got the information we originally wanted.

Our small test system will remain in place even after we finish the larger one. It can still run our lights and other DC loads, and it will offset about 10 percent of our electric demands from our future equipment. We recommend it to anybody on the fence about going renewable.

Access

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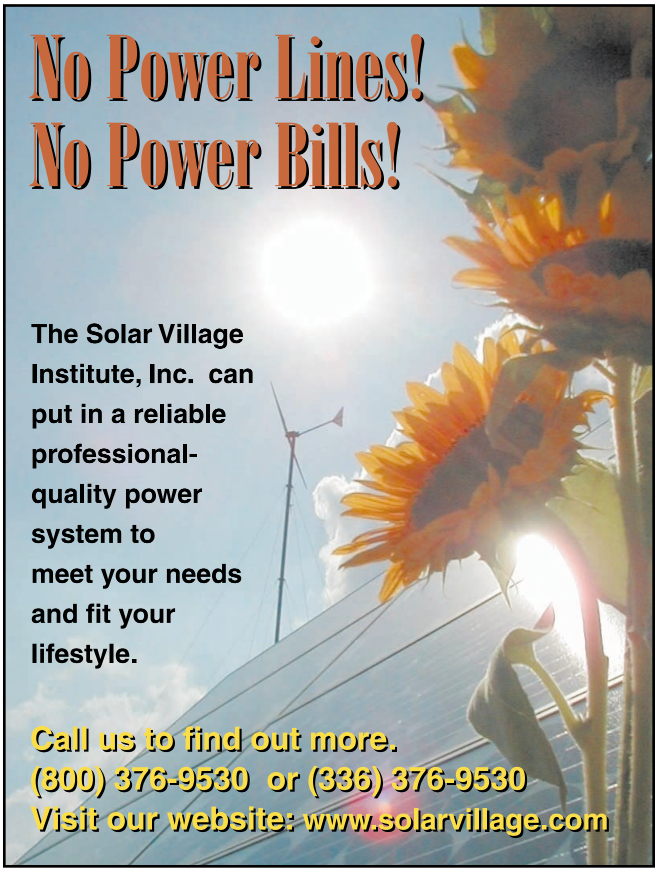

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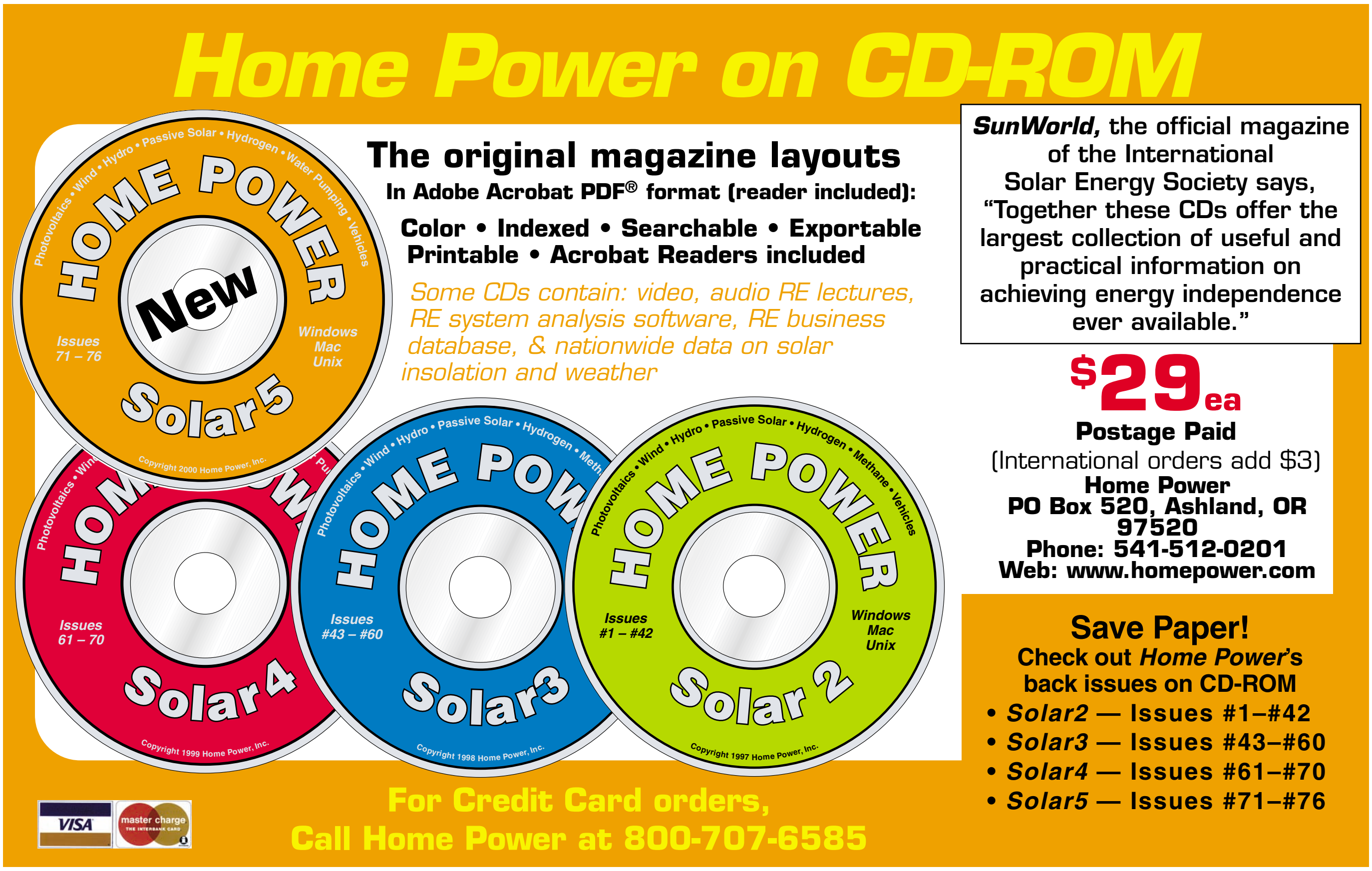

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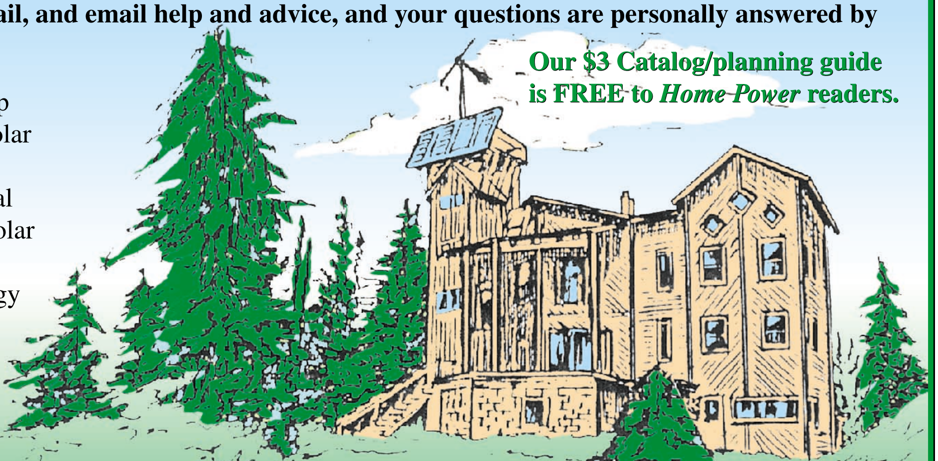

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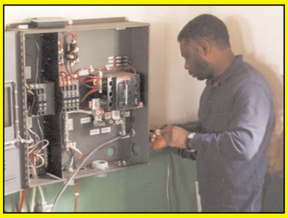

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Utility-Intertied PV Workshop

John Day, Oregon, July, 2000

Richard Perez

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There surely must be something more satisfying than putting solar energy on the grid, but I can't think of it. Every time I get to blow a little sunshine up a coal-burning or salmon-killing utility's skirt, I just have to grin.

Solar-electric systems just don't spring up like mushrooms. They require meticulous planning, mucho ground work before the installation, and a crew that knows what to do. This system at the Grant County Fairgrounds was no exception. It took months of work from many folks to bring solar electricity to the Oregon Trail Electric Co-op.

It all began at the end of the 1999 SolWest Fair. The SolWest and *Home Power* crews were discussing the event over a few beers. I mentioned that we should do a pre-fair workshop and install a permanent PV utility-intertied system at the fairgrounds. The big cheese of SolWest, Jennifer Barker, lit up like a supernova—"Yeah, let's do it!"

And that began months of work, mostly on Jennifer's part. She began canvassing the manufacturers of the gear—would they donate equipment to such a project? Would the local Grant County Fairgrounds be willing to host such a system? Would the local electric utility intertie with such a system? Would the local electrical inspector approve of it all? Would enough paying students show up to meet the mounting incidental project bills? Would we get it all on line in time for the SolWest Fair? Jennifer worked her butt off.

The Workshop

The plan was for Joe Schwartz and me to breeze into town three days before the fair to teach the

All the concrete work was done prior to the workshop.

workshop. The students at this workshop would install a permanent, utility-intertied PV system at the fairgrounds. It worked just like that—well, almost.

Joe and I didn't know what to expect. Neither of us had ever taught this workshop before, even though we'd both done other workshops and utility-intertied PV systems. We finalized our class notes on the long, eight-hour drive to John Day. We felt we were ready.

My major concern was the technical skill level of the students. I needn't have worried. Most of the nineteen students were very familiar with off-grid PV, and some even with on-grid PV. We were blessed with an experienced and energetic group of students. They were a joy to work with.

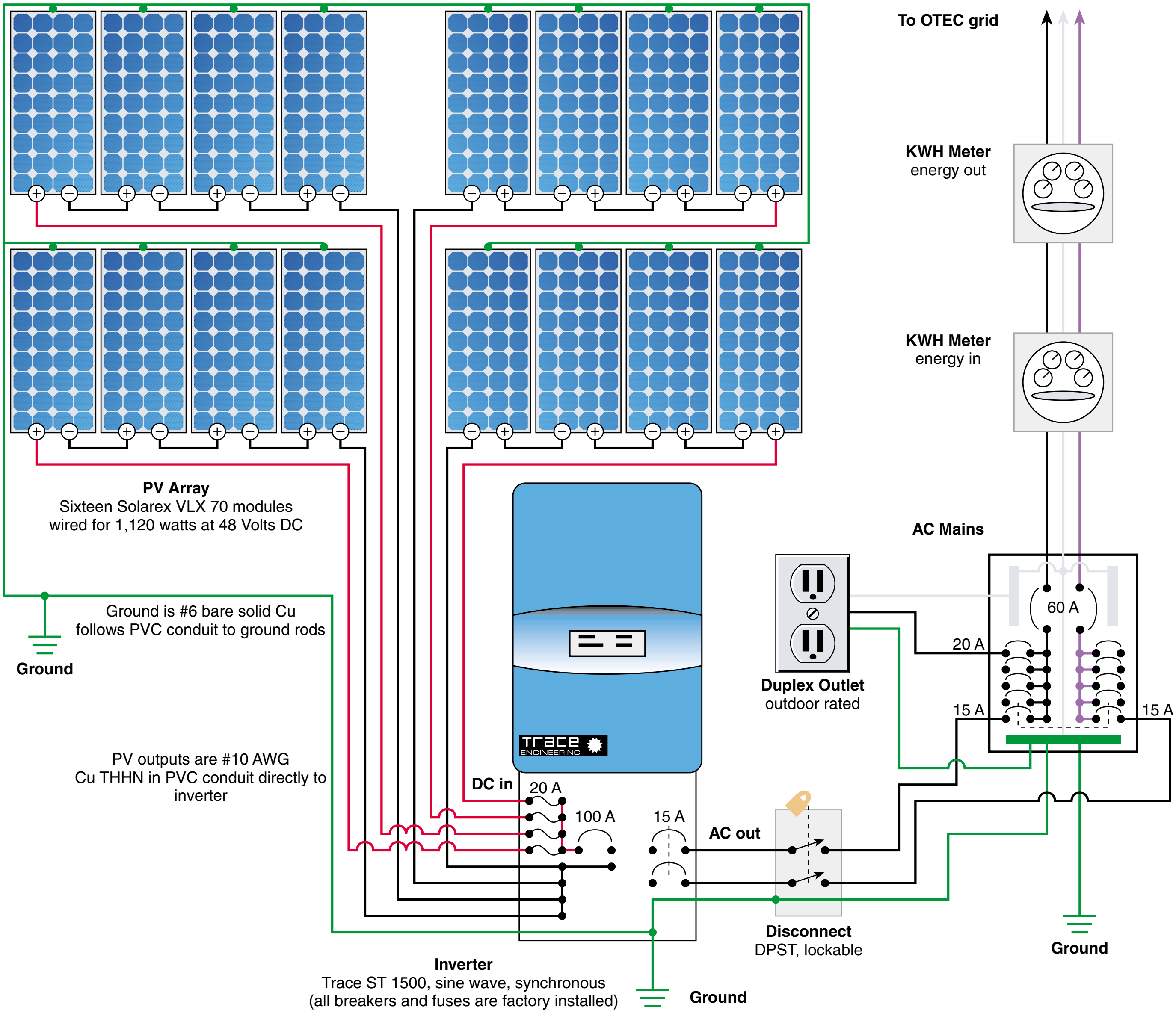
We started the class out with technical information and discussions about how PVs and inverters work. We discussed AC power quality issues, and measured the power quality of the local grid and various inverters using the Fluke 43 power quality analyzer. We discussed energy issues, *NEC®* issues, wire sizing, PV mounting structures, the legal issues of net metering PV systems, and a host of other PV issues.

Joe Schwartz discusses safety issues with the class.

We installed a temporary guerrilla solar system using a couple of the modules and a Trace Microsine inverter. We took some lessons out in the sun with the Solar Pathfinder, and even ran a current versus voltage (IV) curve on one of the modules we were installing. We had a fun-filled couple of days discussing a subject that interested all of us—solar electricity.

Top: A working guerrilla solar system.
Center: Running an IV curve on one of the PV modules.
Bottom: Learning to use the Solar Pathfinder.

SolWest Utility-Intertie PV System



System Design

Batteryless, grid-intertied PV systems are far easier to design than off-grid systems. Since there is no need to worry about the system running out of electricity (provided the utility doesn't fail), a detailed load analysis isn't required. The system components simply need to be sized to handle the PV array's maximum power output. It doesn't get much simpler in the world of solar electricity.

In batteryless utility-intertie systems, there are really only three major components—PV modules, a mounting structure for the PVs, and a utility-intertie inverter. There are no batteries to lug, battery interconnects to manufacture, or charge controllers to wire up and fine tune.

The size of a utility-intertied PV system is limited primarily by one factor—the budget. Since the major system components were to be donated in this case, the limit was the generosity of the RE industry. BP Solar kicked down with sixteen Solarex VLX-70 PV modules with a total rated wattage of 1,120 watts.

Two Seas Metalworks donated two of their hurricane-proof, pole-mount PV racks. Trace Engineering donated one of their brand new 1,500 watt Sun Tie inverters. Many thanks to these companies for giving so freely of

their products. This was going to be a bang-up system on permanent public display!

Jennifer saw to it that the mounting poles were properly installed in their concrete holes, and that all the 120 VAC wiring and utility meters were installed prior to the workshop. Special thanks to Dennis Voigt, a local electrical contractor, for donating his time for the pre-fair groundwork.

Jim Sanders, the local contractor who donated time to put in the PV mount poles, also built support boards of locally milled pine for both the AC wiring and the inverter. He built a mini-house for the inverter and wiring, with locking barn-style doors that could be opened for display.

The Installation—Day One

At noon on the second day of the class, we went out into the intense sun and began the actual installation. Joe and I had counted and checked all the parts the previous day. We paid special attention to the PV racks, and yes, every part was there.

What we didn't know was that due to a communication error, we had the wrong racks. We discovered this chilling fact only after the class laid the modules out on their shipping cartons and began laying out the racks. Everyone froze with "what's wrong with this picture?" looks on their faces. The donated Solarex VLX modules were far wider than what the racks were designed to hold.

Our hearts sank. Here we had a class that had come to install this system. In just 48 hours, the SolWest RE Fair would begin, and this system was going to be on display. If this were a regular home installation, we'd have just sent the racks back and returned to do the installation on another day.

But this wasn't a regular installation; it was a pre-fair workshop. These folks had traveled hundreds of miles and paid good money for the educational experience of actually installing a utility-intertied PV system. We had to do something, and we had to do it very quickly.

Joe and I gave the class an early lunch and began frantically searching for a solution. A quick call to Two Seas confirmed what I suspected. There was no way that they could ship us a rack in time to complete the class and have the system operational by fair time. They had the rack in stock, but there was no way to ship it quickly enough. We were on our own.

Workshop participant Chris Worcester, Joe, and I jumped into the van and began combing the tiny town of John Day for the material we needed. We visited every store we even remotely thought might have aluminum channel stock. We checked out both hardware stores, the welding shop, and even dug through the metal scrap pile at the local glass shop. Finally, we lucked out. The lumberyard had just enough 1 inch (25 mm) galvanized angle iron to extend the racks to accommodate the VLX modules.

Top: Hey, the rack is too small for these PVs....
Bottom: A successful rack klüge using steel angle iron.

Country Klüge
We bought ten 10 foot (3 m) pieces and rushed back to the fairgrounds where the students were just returning from lunch. We set about making strong extensions for the existing racks by bolting together the metal angle stock to form "C" sections. This required much additional drilling and cutting. The class was wonderfully understanding. Most were country "can-do" folks who were deeply acquainted with the art of klüge.

One person in particular was invaluable—Chris Worcester of Solar Wind Works in Truckee, California. Chris may have been a student in the class, but his design expertise and cool head were really what made this klüge work. Even though we had to modify the beautiful Two Seas racks, this klüge would be strong and permanent.

By the end of that afternoon, we had all the modules on the racks and the racks atop the poles. Lifting a rack with four pre-wired modules to the top of the poles was a big job. I was thankful that we had many hands. Before quitting time, we also had the Trace inverter installed in its wooden mini-house and ready for wiring the next day.

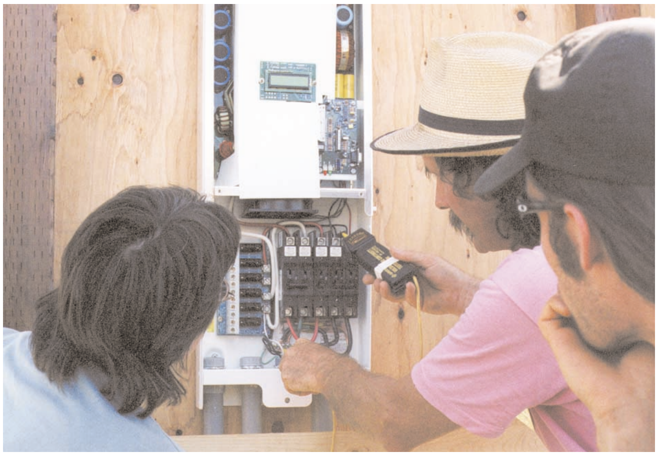
Each PV subarray is composed of four 70 watt modules wired in series, so we had four subarrays on two different racks. Each subarray had its own home run of #10 (5 mm^2) copper wire to the Sun Tie inverter. Each home run was about 40 feet (12 m) in length. All the wiring from the PV array to the inverter was encased in Carflex conduit on the racks and non-metallic conduit for the underground runs.

Trace Sun Tie Inverter
This inverter is a brand new Trace product designed specifically for putting solar electricity onto the grid. It is purely utility-interactive, and designed to work without a battery. It contains individual fuses for each subarray, and all the safety and protection gear required by the *NEC* and the IEEE for utility interconnection of solar electricity. It was a snap to install.

This new inverter has maximum power point tracking (MPPT) that extracts the maximum available power from the PVs, regardless of module temperature or solar insolation. The Sun Tie (ST) inverter also contains a nifty information display that shows grid AC voltage and frequency, array voltage, instantaneous power produced, and total daily power produced. Once the system was installed and working, we were constantly watching this display to see exactly how much solar energy we were putting on the grid.

The Installation—Day Two
After modifying the racks on the first day of the installation, the second day was smooth sailing. All we had to do was hook up the wiring at the Sun Tie and we were on line. We worked at a leisurely pace and finished at about 3 PM daylight savings time (that's 2 PM sun time). After the last connection was made, Joe flipped the circuit breaker connecting the system to the grid. The entire class rushed to the utility meter to watch it spin.

Top: Attaching the home runs to the array.
Bottom: Pulling the home runs through the conduit and into the inverter.



Measuring PV array voltages before putting the Sun Tie inverter online.

A separate service was installed for the fairgrounds' utility-intertied PV system. It consists of a main panel and two unidirectional meters—one for consumption from the grid and the other for solar electricity put on the grid. Why the local utility insisted on two meters was and still is a mystery to us.

Apart from a single duplex receptacle that is rarely (if ever) used, there is no consumption at this service's site. Because the PV system had its own unidirectional meter, it didn't spin backwards, it spun forwards. This led to a lively discussion among the workshop participants, and we decided that henceforth we would term all solar electricity placed on the grid as spinning the meter "forward." A small step forward, but it's definitely in the right direction.

After spending an hour cleaning up the job site, we looked at what we had accomplished. In about sixteen hours of actual installation time, we had put in a system that would deliver four to five KWH of solar electricity to the local electric power grid every day. I'll bet that everyone who helped with this installation will often think about how this system is performing.

Political Aspects

Perhaps the greatest lessons we learned from this system were not technical, but political—as in "of the people." This solar-electric system is all donated. The manufacturers donated over US$8,000 worth of solar-electric equipment—PV modules, mounting racks, and inverter.

The crew.

Jennifer and her local assistants donated US$2,000 for the groundwork of poles, holes, concrete, wire, and conduit—all of it installed and inspected before the fair. The students donated—no, actually paid for—their labor of learning and installing. Joe and I donated our time and expenses. We all—from industry biggies to on-point grunts—freely gave what we had to give. This was a labor of love and hope.

I wish I could include the Oregon Trail Electric Coop (OTEC) in the list of folks who were giving because they believe that solar electricity represents a better future for us all. But I can't.

OTEC is like many small rural electric coops. They seem to see locally-produced solar energy as a threat to the way they have always done business. It's a change in a structure that isn't used to change. OTEC insisted on two meters, and rightfully under the Oregon net metering law, installed them at their own expense. OTEC is pursuing an agreement that would net these two meters against one another. Since there is no regular load on the grid meter, there is no usage for the PV meter to net against. This qualifies all the energy that these PVs produce as "monthly excess."

Under Oregon's net metering law, monthly excess energy is either granted to the utility or sold to them at avoided generating cost. This system, the result of so many people's generosity and hard work, isn't really a net metering system at all. It's a donation of solar electricity to OTEC's grid.

To add insult to injury, OTEC is now trying to insist on a US$15 per month meter reading fee (the PV system makes about US$7 worth of electricity per month). They even went so far as to suggest a US$15 fee for *each* meter when they formalize their net metering policy.

But wait, there's more…. Off the charts is their latest proposal of a US$35 annual inspection fee so that they may determine that this peanut-whistle PV system is not a danger to their grid.

A Legacy for the Future

Technology and politics aside, the real accomplishment of this system is a daily average (so far) of 4.33 KWH placed on the grid. This will go on day after day for years. This system will just keep on pumping out the electricity as long as the sun shines.

Over the next twenty years, this small system will displace 20 metric tons of CO_2 that would have been produced to make the same quantity of electricity. All the folks who worked on this system have left this amazing new source of electricity as a legacy to the future. I salute them!

Hoops & Hurdles

Jennifer Barker

©2000 Jennifer Barker

Getting permission from the utility to install the system at the fairgrounds was easy. The new net metering law, Oregon HB3219, says that the utility has to allow grid-intertied PV, and they were going to obey the law. No mention was made of extra costs or charges, because the law had just been passed, and Oregon Trail Electric Cooperative (OTEC) had no idea what their policy would ultimately be.

Dealing with OTEC's engineering department was easy too. Busy as he was, Chief Engineer Mike Chase was frequently in John Day for meetings, and was always willing to return my phone calls and get together to discuss configuration. His main concern was how they would meter a system that would produce more power in a month than was being consumed. He recommended two meters for our system.

Grant County's planning department was very cooperative. They looked at the wiring schematic and declared the solar installation to be a "branch circuit" because it did not have a subpanel. So the additional cost on the permit already issued for the main panel and utility hookup would be US$3.

Trouble Comin'

The first indication of a potential problem was when I received a desperate email from Tom Wykes, Oregon State Extension energy agent in Bend. Comment was needed quickly. Central Electric Coop was formulating their net metering policy and proposing prohibitive fees. My contact at OTEC informed me that they would soon be following suit, and I asked for a copy of their proposal as soon as it became available.

OTEC was proposing administrative and inspection fees of US$131 annually for net metering customers over and above the base fees and power in/out. This would make net metering a loss to almost all customers with the 25 KW-or-under systems allowed by the law. When the co-ops negotiated for the terms of the law, they promised to "make it work." But this was not working. In fact, it was worse than no law at all!

OTEC's concern was that distributing the cost of administration (hand billing in case of negative meter readings) among all their members would amount to a "subsidy" of the net metering customers, and raise the bills of all their customers.

Speak Up!
The law said they had to take public comment. The hardest part was lining up people who cared enough to drive the miles to the OTEC office in Baker City and comment in person. We had exactly two and a half weeks notice, and only two weeks for written comment to be submitted. Six dedicated RE supporters attended the meeting, and one other whipped out a letter of comment in time.

SolWest organizers: Ken Primrose, Nancy BeBout, and Jennifer Barker.

OTEC was represented by their general manager, member services manager, head of accounting, and chief engineer. The purpose of the meeting was for these people to collect our comments, digest them into suggestions, and later present them to the board of directors.

The comments made by EORenew members were very sharp. They represented all levels of personal experience, from Kay Firor and Kent Osterberg who had operated a permitted grid-intertied system on their house for many years (with no extra fees!) to Chuck Koch, proposing to install a 15 KW Jacobs wind genny as soon as possible, to Linda Harrington, who dreams about adding a solar-electric system to her bed and breakfast in Prairie City.

Since I am not an OTEC customer, I was regarded with some impatience as an "activist." But the OTEC members and a local installer were listened to very courteously. Some of us had our comments in written form, and these were accepted at the meeting. I don't know what the board's decision will be in the end, but from the rumors, we had more turnout for comment than any other utility.

Do Your Homework
People whose utilities are proposing prohibitive policies towards RE on-grid need to buckle down and do some serious research. The folks who came to the meeting had done the homework. We had contacted our friends in the business, learned the technical aspects of the safety issues, and found out how other utilities are dealing with net metering and how they regard RE on-grid as a benefit.

Without being confrontational about it, we made OTEC realize that they were acting like they were afraid of the dark. If you want to get your utility to back off, offer help and support for the learning process that these utilities must go through. We have the contacts and the information they need, and we should offer it freely.

Wanted: RE-Friendly Policy
For now, the fairgrounds' system is being net-metered as they all should be—retail in, retail out, and no extra fees. OTEC emphasizes this policy is only for us, and only until a formal policy is instituted. Perhaps even if they charge fees for regular customers, we can get them to leave the fairgrounds as it is now, because it is a public demonstration on a not-for-profit property.

But that is not enough. We want the whole thing—not a handout, but a fair and forward-looking policy that encourages all their members to put distributed, RE-based generation on the grid!

Access
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info@solwest.org • www.solwest.org • SolWest 2001, July 28–29, Grant County Fairgrounds, John Day, Oregon

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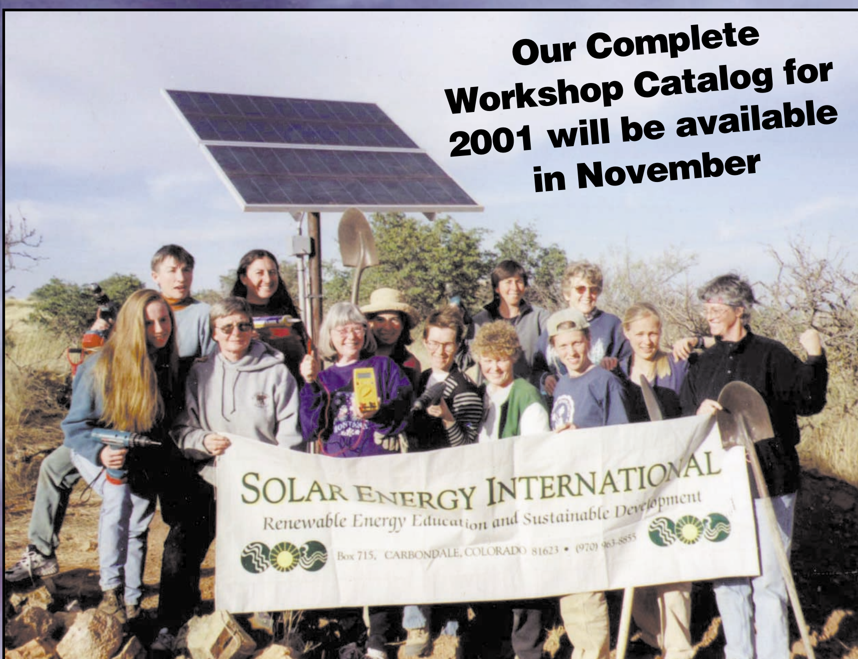

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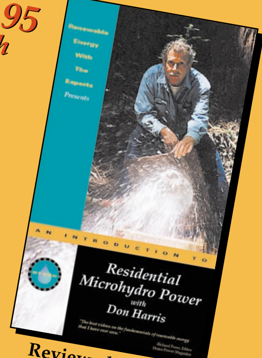

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Residential Solar Electricity with Johnny Weiss, 48 min. Johnny Weiss is one of the founders and teachers at Solar Energy International, in Carbondale, CO.

Residential Wind Power with Mick Sagrillo, 63 min. Mick Sagrillo has installed and repaired over 1,000 wind turbines.

Residential Microhydro Power with Don Harris, 44 min. Don Harris has designed and manufactured over 1,000 microhydro power plants.

Batteries with Richard Perez, Editor in Chief and founder of *Home Power* magazine.

Solar Water Pumping with Windy Dankoff, 59 min. Windy Dankoff has been designing and installing solar-powered water pumping systems for 15 years.

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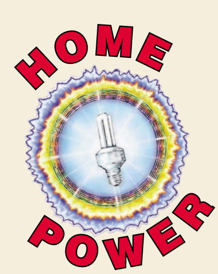

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SOL WEST Renewable Energy Fair 2000

Richard Perez

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What makes folks travel for hundreds, even thousands, of miles to spend the weekend talking renewable energy with others? An energy fair, that's what!

While John Day is a small town located in the middle of eastern Oregon, it is well on its way to becoming a mecca for RE enthusiasts. SolWest 2000 drew over a thousand folks from sixteen states and Canada. They came from as far away as Massachusetts, New York, Vermont, Mississippi, Oklahoma, and Illinois.

Second Year in a Row!

Getting an energy fair to happen just once is an accomplishment. Getting it to happen a second time, and having the event surpass the first, is a supreme accomplishment.

Jennifer Barker and her crew of SolWest workers pulled it off again this year on July 29th and 30th, and bettered their first event. If you were there, I hope these pictures will bring back fond memories. If you didn't attend SolWest 2000, here's what you missed.

A Great Meal is the Way to Begin

I've attended over fifty energy fairs in the last ten years. Most start with an exhibitors' dinner. Out of all these fairs, I must say that SolWest has the best food. And SolWest's "networking dinner" is open to anyone who is interested, not just exhibitors.

The day before the fair began, Joe Schwartz, Eric Hansen, and I went to Jennifer and Lance Barker's homestead, Morning Hill Forest Farm. Their place is amazing. Jennifer and Lance run their homestead without fossil fuels. The only gas consumers are their vehicles and a chainsaw. Everything else runs on solar and wood. They have no backup generator and use no propane on their remote mountain homestead. I've asked them to write an article about their homestead for publication in *Home Power.*

One main feature at this homestead are Lance's gardens. Considering the 5,000 foot (1,525 m) plus elevation, these gardens are more than amazing, they border on impossible. Almost all the vegetables served at the SolWest networking dinner came from Lance's gardens. As we wandered through these extensive gardens, Lance introduced us to each of the many veggies scheduled for the dinner.

These healthy and beautiful veggies, coupled with locally raised organic beef, made for the best exhibitors' dinner I've ever attended. Many thanks to Lance Barker for sharing the fruits of his herculean labors with the SolWest attendees.

Featured Speakers

Randy Udall from the Community Office for Resource Efficiency (CORE) in Aspen, Colorado was the keynote speaker on Saturday. His use of humor in his slides and examples brought home the point that we have to be serious about examining our energy use and sources. Randy is an accomplished speaker—he left his listeners inspired.

John Perlin, author of *From Space to Earth: the Story of Solar Electricity,* was the keynote speaker on Sunday. John explored the history of man's use of solar energy and solar electricity. Also a featured speaker both Saturday and Sunday was Steve Roberts of Nomadic Research Labs. Steve discussed what he terms "Technomadics" with SolWest fairgoers.

Workshops

One of the reasons energy fairs are so popular is the workshops. Workshops offer folks the opportunity to learn about renewable energy technologies and how to use them. No matter the topic, SolWest had a workshop on the subject, each taught by a hands-on expert. In all, there were 33 workshops during the fair, covering solar heat, PV, net metering laws, solar tax credits, fuel cells, wind power, inverters, batteries, and more.

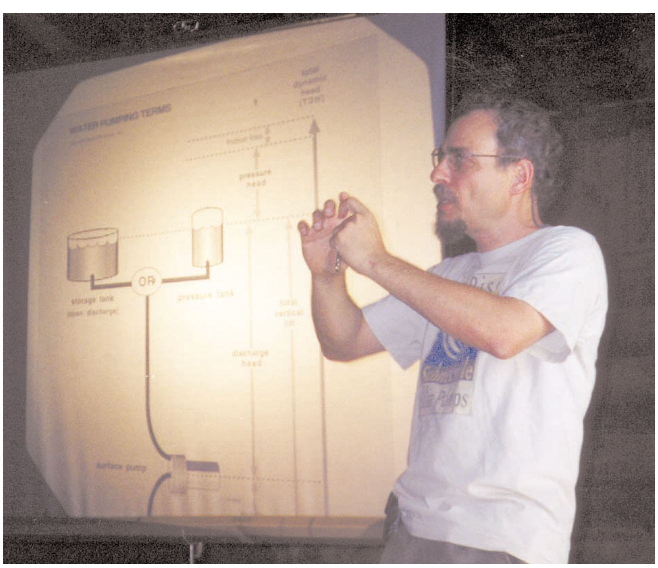

photo by Heather Sheedy, courtesy of the Blue Mountain Eagle

Windy Dankoff teaches solar water pumping.

Exhibitors

The heart and soul of any energy fair are the exhibitors. They are the folks teaching the workshops and meeting you one on one at the booths. Most exhibitors are by necessity commercially oriented—they must make sales at a fair in order to survive and return again the next year. While the crowd at SolWest 2000 was not large, they were serious about going home with RE gear to install. They came with checklists and checkbooks.

Top: Sunelco and Kyocera talk solar.
Center: Solar Depot does the same.
Bottom: Oregon Office of Energy helps you pay for it.

Bob Maynard of Energy Outfitters told me that he sold out by 11 AM on Saturday. The folks at Sunelco said that they sold more RE gear at SolWest than in their previous four fairs combined. I saw many fairgoers carting equipment out to their cars. This commercial aspect of energy fairs is wonderful. What's the use of knowing the technology without the hardware necessary to actually use RE? Users got great deals

Steve Roberts and his Microship.

with fair specials, and exhibitors went home with full wallets and empty trucks.

Not all of the exhibitors were commercial. Some were purely informational. For example, the State of Oregon had a booth explaining to folks about the RE tax credits in Oregon. An exhibitor that really caught my attention was Steve Roberts and his Technomadics research.

GoPower!

I first ran into Steve at the first SEER fair in Willits, California in August, 1990. Steve was astride his totally wired bike. This bike had most every two-way radio possible, and several computers too. It was all solar and pedal powered. It was totally nuts, and Steve had already put thousands of miles on the rig.

Steve is a technical wanderer. His chosen fields are electronic technology and the surface of this planet—he wanders both. His dream is total free mobility with a fast Internet connection. Steve's bike was just the beginning—now he's into water. Steve and his partner Natascha were at SolWest displaying their Microships.

These live-aboard, 17 foot (5 m) sailing trimarans are the most intensely and tightly engineered boats I've ever seen. They have three motive sources—sail, pedal, and solar-electric. They even have retractable wheels for easy, damage-free beaching. They have almost every known form of radio communication aboard. All this communications gear talks to multiple onboard computers. If Steve's wired bike was nuts, these microships are from another planet. While we discussed sailing, PV, radio communications, and computers, I marveled at the experience. Where else but at an energy fair can you meet and talk to such people?

Christoper Dymond demonstrates the Honda Insight.

More GoPower!
Christopher Dymond of the Oregon Office of Energy was at SolWest with the OOE's new Honda Insight hybrid electric vehicle. Christopher gave me a ride and it was quiet, smooth, and fast. Christopher drove the vehicle from Salem, Oregon to John Day. This is a long trip over several mountain passes. He averaged 72 miles (116 km) per gallon of gas. He said he turned off the air conditioner only while climbing hills....

If the 100 degree heat made you lethargic, there's nothing like a car race to wake you up. SolWest had Electrathon racing. See Eric Hansen's article following this one for a report on the excitement. Eric actually drove in the race. Joe and I tried to be Eric's pit crew, but armed only with two Leathermans, two hours warning, and no spares, I'm afraid we weren't much help.

Fantastic Fun
No one would go to these fairs if they were a drag. These fairs are the finest form of fun. The fairgoers get their questions answered, and they get great deals on equipment. All the exhibitors get to talk shop. Everyone, yes everyone, learns more than a few new things. At night the distinction between exhibitor and attendee blurs. Everyone gathers around a common light. The solar-powered daiquiris flow. Hopes and wishes take on form. Music and song rises. If you weren't there, you really missed something.

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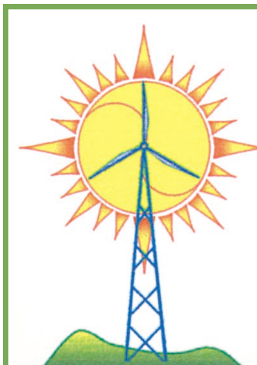

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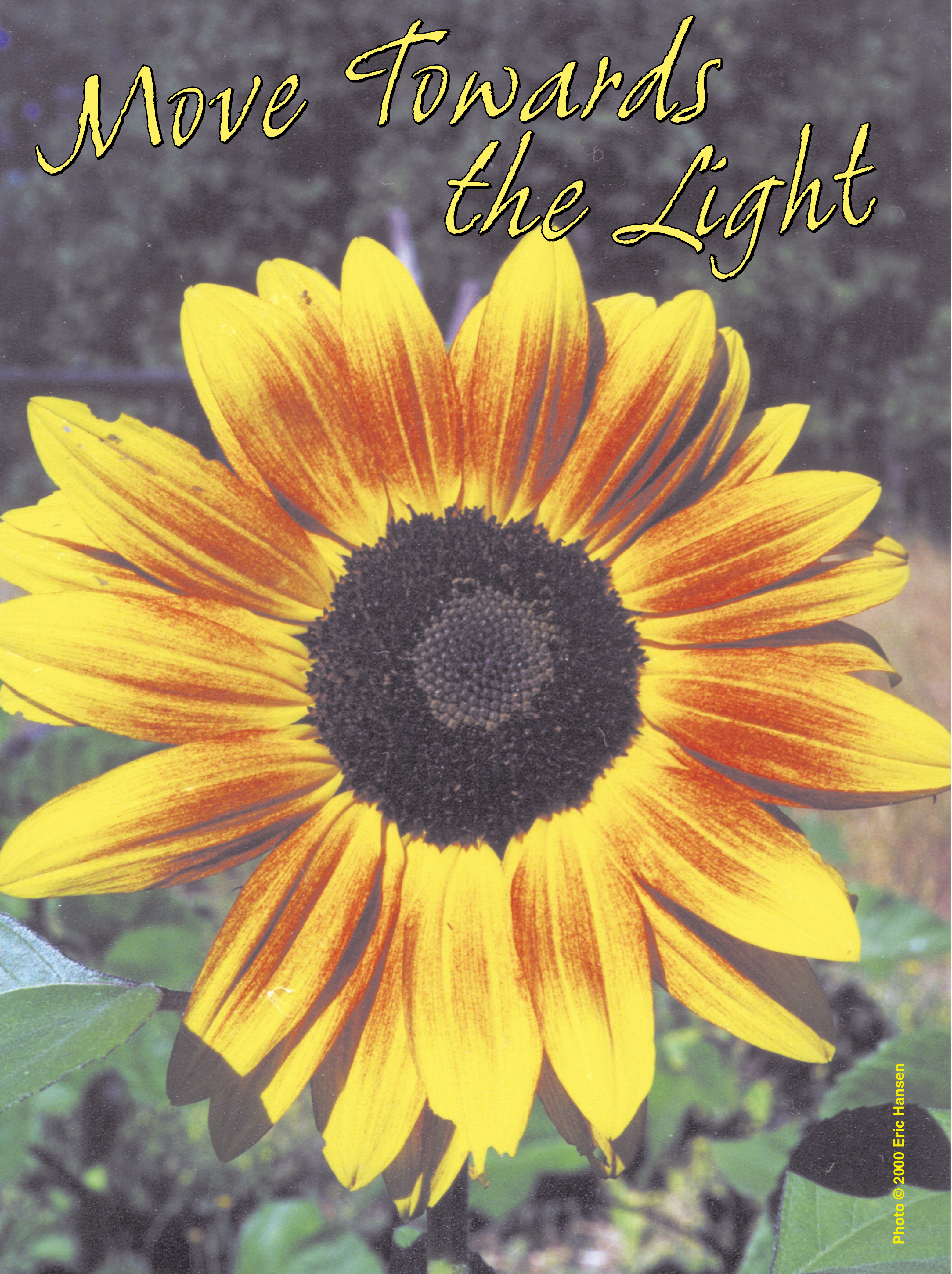

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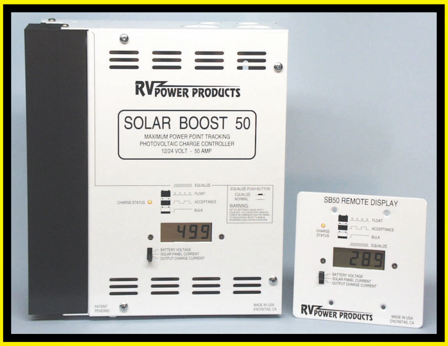

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Adventures in Electrathon & Grease Power at SolWest

Eric Hansen

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Vehicles at SolWest's second annual energy fair ripped it up with electricity and grease! An exciting Electrathon race and the introduction of the "Grease Car" highlighted the event's rolling stock. I was able to jump in the driver's seat of an Electrathon racer for a brief, yet epic, adventure. And those who met the Grease Car's crew learned of their evangelical cross-country experiment.

Jennifer Barker worked with Electrathon America to bring the first Electrathon race to the SolWest Renewable Energy Fair. When the event's details were arranged, the national organization approved it as a sanctioned Electrathon America race. The local auto club, the Grant County Kruzers, helped out by sponsoring a special award for the best high school vehicle.

The main competitors were Cloud Electric Racing, Willamette High School, Hewlett Packard ENV Team, and Morning Hill Associates. Dave Cloud is an experienced and innovative designer and builder of these racers. Ron Breckon, another Electrathon competitor, is a recycling and alternative energy and transportation enthusiast. He's recently gotten involved in the Electrathon by bringing two of Dave Cloud's racers out of retirement. And he's hoping to organize an Electrathon race in Washington state.

Give Me the Keys, I'll Drive

Ron didn't have to talk me into driving his second Electrathon racer. I had been eyeing the cool vehicles from afar, and was hoping for a shot at competing. My vehicle, a three wheeled silver bullet, boasted a respectable motor, but lots of duct tape. As we warmed up the batteries in a heated foam cooler to top them off, Ron gave me the lowdown on how to drive an Electrathon racer.

My race strategy was this—quick and consistent. I was going to go easy on the brakes, light on the throttle, and allow the vehicle to coast as much as possible, taking advantage of its aerodynamic and light construction. Ron warned me that attacking the track with a fast and furious pace would prematurely drain the batteries and kill the tires.

Eric Hansen, powering into a sharp turn in the Electrathon racer.

But as the *Home Power* pit crew taped the sleek lid onto my machine, I changed my tune. As the race began, my levelheaded strategy fell victim to adrenaline. I quickly became wrapped up in staying with the pack and taking the sharp turns with the throttle down. What fun—I felt like I was flying in my racer! The fact that the car is only inches off the ground makes twenty miles per hour feel like sixty miles per hour.

As I skidded around my fifteenth lap, I encountered my first challenge. The lid of my vehicle was coming off. I guess the duct tape that fastened it down didn't hold too well. Now it was totally askew, and my mirrors weren't working for me—I couldn't see my fellow racers. I was a liability, and didn't want to hit anyone.

I took myself out of the race for a few seconds and made the racer into a convertible. No worries. Now, back in the race, pieces of the track and debris from other cars' tires bounced off my sunglasses. I was keeping up with the shredders from Willamette High School pretty well when boom, grind, scrape—I lost power.

I exited the track near my pit crew—Richard Perez, Joe Schwartz, and Rose Woofenden. Rose quickly diagnosed the problem—my chain had fallen off and was munched up in the nose cone. Richard was swift to lend his Leatherman tool. Joe and I got the nose cone off and the chain back on.

Back in the race, without a lid or a nose cone, I was looking funky, but doing OK. I was skidding around the corners with the best of them until… *Pop!*—one of my tires blew. Yipes! My pit crew was all the way across the track, but it didn't matter this time. We didn't have spare tires in the *Home Power* booth. It was the end of the race for me.

The track's rough surface and hot temperature made it hell on wheels. The tight design of the course made it hard to coast the Electrathon racers. One long straightaway allowed for some coasting, but in order to stay competitive, the racers had to power through the six quick turns. The quick turns ate up energy from the batts and chewed up tires. Even so, several of the fourteen participants finished with over a hundred laps. My 70 laps looked pretty meager on paper compared to the 289 laps Bruce Sherry of Cloud Electric Racing racked up.

The race was a prominent exhibition at the fair. The crowd loved it. Fairgoers got the opportunity to see this technology firsthand. Some got the bug to engineer racers themselves. *Home Power,* along with Larry Elliott of Klamath Advanced Transportation Technology & Energy Lab (KATTEL) and Bob Maynard of Energy

Teamwork—*HP's* pit crew fixing the chain.

Outfitters, are working on an Electrathon racer to premier in 2001. This alliance will be promoting Electrathon races in Grants Pass, Ashland, and Klamath Falls, Oregon.

Introducing the Grease Car

Justin Carven's converted 1982 VW Westfalia Vanagon is journeying across the country and back on used cooking grease. That's right, grease! *Home Power* caught up with the Grease Car crew after SolWest's biodiesel workshop.

The Grease Car runs on fuels ranging from bacon grease to light salad oils. Using a dual fuel tank system, the motor warms up on conventional diesel or biodiesel and switches over to grease. As the engine runs, a copper coil heats the tank. When the grease becomes warm enough to pass through the motor's components, it's ready to be burned. At the end of the day, the tank is switched again to flush the cooling oils. And yes, the exhaust smells like a plate of bacon, fried eggs, and hash browns.

From the Grease Car Trip Log, July 29, 2000

We're now in John Day, Oregon at the SolWest Renewable Energy Fair. We ran into Jon Kenneke, the SlugBus guy, who runs his VW on biodiesel. He was psyched to see us with the Grease Car, since he blew a head gasket on the way here. He gave a talk on how to make biodiesel, and mentioned us and the system that Justin got going. People are pumped! The folks out west seem so open to anything.

There is another one of those Honda hybrid electric cars here, and lots of solar technology. In fact, I think there is a deal going down with some of the solar guys and some of the grease guys—grease technology for solar technology. Justin isn't really a solar advocate, but by the end of the day, the Grease Car will be equipped with solar panels that will power our fridge, cell phone, and laptop.

The Grease Guys: Skip Wrightson (left) and Justin Carven (center).

This Grease Car is an evolutionary step in Justin Carven's experimental use of used cooking grease as a viable diesel alternative. He and Skip Wrightson set out from Cape Cod, Massachusetts on June 30, 2000 to log some 10,000 miles (16,000 km) in the Grease Car—refueling at restaurants.

If the cross-country experiment proves successful, Justin hopes to market a retrofit kit. The product will allow the user to quickly install a simple conversion that burns a variety of clean and dirty oils stored in the filtering tank of a diesel car or truck.

Justin converted the first Grease Car from a 1984 VW Quantum turbo diesel, building on his previous work with the Bio-fuels Project at Hampshire College. The Quantum logged 2,000 grease miles (3,200 grease km) before the car was retired. Justin and Skip then converted the 1982 VW Westfalia Vanagon using the Quantum's swapped out diesel engine. Check out their Web site for an overview of this process and the tools it took to convert it. Project Grease Car is funded by the National Collegiate Innovators and Inventors Alliance.

Congratulations to Justin and Skip on the Grease Car and journey. What an awesome experiment, adventure, and renewable outreach these two guys undertook. They truly succeeded in spreading the greasy word about renewables.

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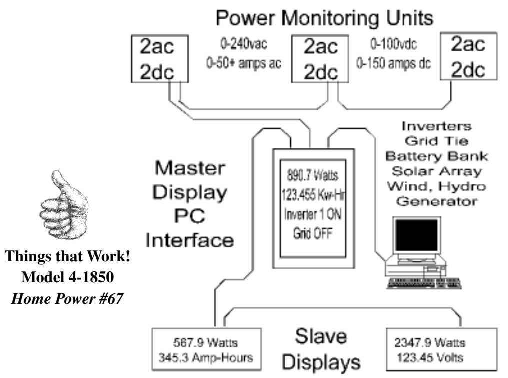

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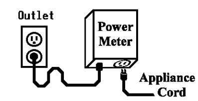

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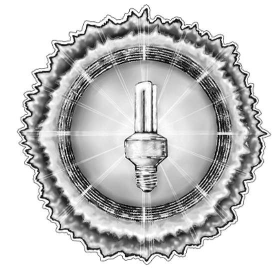

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Sir Thomas Lipton — 1870

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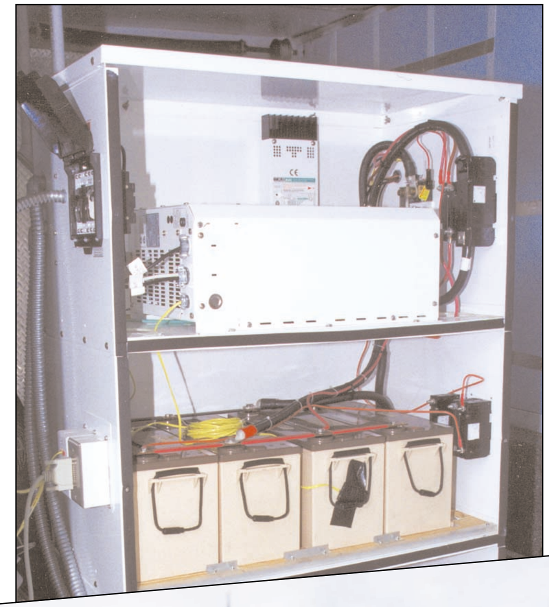
TOP SECRET

GUERRILLA SOLAR: The unauthorized placement of renewable energy on a utility grid.

PROFILE: 0012



DATE: October, 2000
LOCATION: Somewhere in the USA
INSTALLER NAME: Classified
OWNER NAME: Classified
INTERTIED UTILITY: Classified
SYSTEM SIZE: 450 watts of PV, 400 watts of wind
PERCENT OF ANNUAL LOAD: Classified
TIME IN SERVICE: Classified

Several families in my area have a passion for serving the community with portable emergency communications gear powered by renewable energy. When we hook up our systems at home, we have to use guerrilla tactics.

I want to install a utility-intertied wind turbine, but I've been facing some obstacles. Zoning states that the blade diameter must be 8 feet or less. The tower also needs a special use permit, which costs $700 every time the permit is submitted for approval. The catch is that no one has been able to tell me the average number of times these permits have been resubmitted. In addition to this red tape, no one has been able to make it through the utility approval process.

I'm trying to show the government and utilities that RE can work for everyone's benefit. Community service takes on many forms. For me, guerrilla solar is community service--it provides power for emergency communication. When storms, floods, or fires wipe out the infrastructure of a city, a network of people operate this portable radio station, serving government and relief agencies.

Our power trailer allows us a high degree of flexibility--we do grid-tie, remote power, radio base, and first aid.

System inputs are 450 watts of PV from Helios modules, and 400 watts of wind power from an Air Industrial 99. The modules are hooked up in series pairs and then paralleled for a 24 volt array. We have eight Liberty 1000 batteries, hooked up in a 24 volt configuration. Our Trace SW4024 is housed in a three-cabinet Trace Power Module. To provide power during rolling blackouts, we have a Honda 10 KW AC generator converted to propane, and a 24 volt, 1.5 KW, DC military gasoline generator.

The power trailer connects to the house with a GenTran transfer switch, allowing the system to power ten different circuits in the house. The DC and AC connectors for the modules and wind turbine have been standardized within the local RE community, so that we can combine systems quickly and efficiently.

In the future, we are going to finish loading up a tracker with more PVs, and using an auxiliary solar input, add solar capacity when the power trailer is home.

The obstructionist tactics of the utilities and their pals in government are not serving the community. So this community has chosen to serve its neighbors via guerrilla solar and wind energy.

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RE Lab Experiment #1:

Welding Cable ACID Test

Drake Chamberlin

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Cable specimens soaking in battery acid.

The Renewable Energy Test Lab has conducted its first experiment. The lab is dedicated to defining and promoting safe and cost effective methods for the construction of renewable energy electrical systems. We believe that system costs can be significantly reduced by using only what is truly necessary for system safety and efficiency.

In recent years, inspection agencies have become interested in photovoltaic and other renewable energy (RE) installations. An effort has been made by the *National Electrical Code* to define requirements for these systems. Manufacturers and Underwriters Laboratories also specify conditions for certain system components.

Safety & Common Sense

Solar and other RE systems were being installed for at least a decade before code compliance became an issue. (Wind systems go back many decades.) During this period, many pioneers in the field developed safe and effective methods of constructing systems. There were remarkably few safety problems with these early systems.

When code enforcement began, it was welcomed by many. Some early systems did not use fuses or follow other basics of good electrical design. But as code enforcement developed, it quickly became apparent that the experience of RE pioneers had not been taken into account when drafting the new regulations. Requirements were added that drove up system costs, without benefit to safety or performance. Bob-O Schultze's early *Wrench Realities* columns in *Home Power* documented many of the concerns.

Welding Cable

One area where new requirements ignored the experience of RE pioneers was in the banning of

Ideal Sperry 61-780 Insulation Tester Results for Cable Insulation Test

Tested Cable Insulation	*Date In*	*Date Out*	*Visible Change*	*Meter Reading*
#2/0 AWG THW or Oil Resistant I	4 Mar	7 Aug	none	OL**
#2/0 Essex Excelene welding cable	5 Mar	7 Aug	none	OL
#4/0 Cobra Wire & Cable X-Flex (Trace cable)	4 Mar	7 Aug	none	OL
#4/0 Carol Prene welding cable, 600 V	4 Mar	7 Aug	none	OL
#4/0 Carol Super Vu-Tron type W RHH or RHW	4 Mar	7 Aug	none	OL
#2/0 Hypalon diesel locomotive cable	25 Feb	27 Aug	none	OL
#2/0 Essex THHN or THWN*	4 Mar	21 Apr	loss of mass	OL

* This specimen spilled on 21-Apr, but remained in a puddle of acid until 06-Aug.

** The "OL" reading means resistance is beyond the range of the meter.

welding cable from use in battery boxes. Welding cable has proven to be an effective material to use for connecting batteries to each other, as well as to disconnects and inverters. Welding cable is readily available, very durable, and relatively inexpensive. Many national suppliers of RE equipment still use welding cable for battery interconnects.

The banning of welding cables from battery enclosures is a perfect example of an institutional barrier. Although welding cable has been used successfully for years in battery boxes, it is not listed for this purpose. Its use has been actively suppressed by regulatory agencies.

Several years ago, inspectors in many areas began to reject systems where welding cable was used. They required cable types that were more expensive, and often hard to get. System rejection has caused many RE electricians to be humiliated in front of their customers. It is often necessary to have exotic cables shipped in, sometimes causing stressful delays in system approval.

RE electricians are happy to do whatever is necessary to construct safe systems. But few electricians believe that the zealous suppression of welding cable is in any way justified to obtain that safety.

What to Test

We first needed to determine what the differences are between welding cable and the cables approved by the *NEC.* Most of the popular, acceptable battery cables have conductors composed of finely stranded copper wire. Welding cable conductors are also made from finely stranded copper wire. The difference between the cable types is in the insulation. The concern is the presence of battery acid in the cable's environment.

The issue to be determined was whether or not welding cable insulation is sufficiently resistant to battery acid to justify its use in battery boxes. Would there be any catastrophic reaction if welding cable was subjected to contact with battery acid? Would the insulation dissolve or lose its resistance to electrical potential?

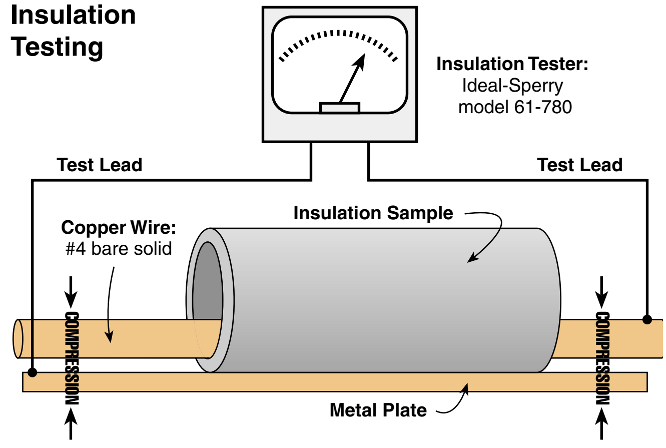
The Acid Test

Several samples of cable sheath were removed from their copper cores. The cables ranged from welding cable to various cable types currently deemed acceptable for use in battery enclosures. The cable samples were all roughly 2 inches (5 cm) in length.

Ideal-Sperry 61-780 Insulation Tester on the 1,000 Megaohm Test

	Megaohms	*Deviation*
High reading	940	6.0%
Low reading	928	7.2%

Insulation Testing



All of the samples were submerged in standard strength battery acid by March 5, 2000. Each specimen went into an individual glass jar. One sample jar was tipped over and mostly emptied of its acid by a squirrel on April 21st. This was a specimen of cable that is not approved for use in battery boxes, and not commonly used—type THHN-THWN.

All of the specimens were removed from the acid on August 6, 2000. They were then dipped in a solution of water and baking soda. All samples, including the spilled specimen, fizzed dramatically when doused in the soda solution. All specimens were then thoroughly rinsed in cold water, dried, and stored in labeled envelopes. Later, they were examined and tested for electrical resistance.

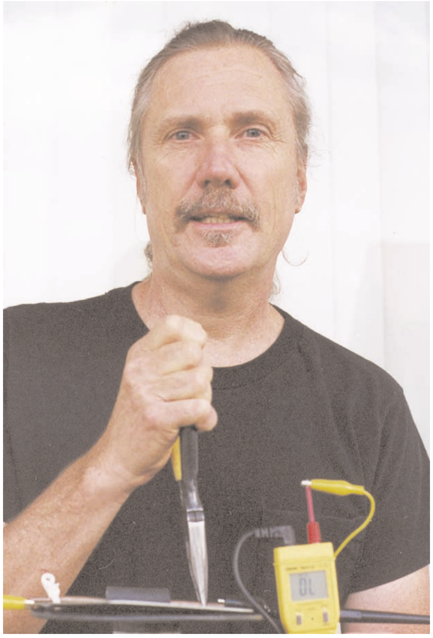
The Results

The only specimen to show any visible deterioration was the THHN-THWN. Within a day or so of being immersed in the acid, it began to darken the solution. Within a week, the solution was black. The insulation was apparently losing mass.

Measured Resistance of Individual Resistors

	Test Instrument		
Resistor Number	*Ideal-Sperry 61-780 Insulation Tester (Megaohms)*	*UEI DM 383 Digital Multimeter (Megaohms)*	*Soar 3200 Digital Multimeter (Megaohms)*
R-1	9.99	10.03	10.04
R-2	9.70	9.72	9.78
R-3	9.82	9.88	9.93
R-4	9.82	9.80	9.90
R-5	9.57	9.63	9.70
Average	9.78	9.81	9.87
Deviation	2.2%	1.9%	1.3%

To determine accuracy of the insulation test meter, resistors rated at 10 megaohms were tested.



Author Drake Chamberlin, testing a sample of welding cable insulation.

After more than five months of soaking in acid, all the other specimens came out of the solution with no signs of degradation. The two samples of welding cable remained flexible. They maintained mechanical integrity, as evidenced by the inability to damage the sheath by twisting and pulling.

The electrical resistance of the samples was tested with an Ideal-Sperry 61-780 insulation tester. This device applies 1,000 VDC to the material being tested. It will test for resistance values up to 2,000 megaohms, or 2 billion ohms.

The accuracy of the meter was investigated by testing 10 megaohm resistors, individually and wired in series groups. One test involved one hundred 10 megaohm resistors wired in series. That adds up to 1 billion ohms, or a gigaohm! The tests demonstrated that the accuracy of the meter was adequate.

The meter readings showed less resistance than the theoretical value of the resistors. The resistors were rated for a 5 percent variation. If the insulation tester was off, it appears that its readings were conservative, showing less resistance than the material being tested. The total variation is insignificant to the hypothesis under investigation.

The samples were tested by inserting a bare #4 (21 mm^2) copper wire through each empty tube of insulation. The sample wall was squeezed between the bare copper wire and a metal plate. One electrode of the tester was attached to the wire, and the other to the plate. Each piece of insulation was tested repeatedly. A short circuit connection was made between the plate and the #4 copper wire after each test to verify the connections.

The bottom line is that none of the insulation specimens registered any conductance whatsoever. Even the sample of THHN, which partially melted in the acid, showed resistance beyond the range of the meter.

Conclusions

The insulation specimens had hundreds of times more exposure to battery acid than cables would in real systems. The welding cable, which we are forbidden to use, showed no signs of being damaged by prolonged submersion in battery acid. The welding cables tested are excellent products for use in battery enclosures, and their use should certainly be permitted.

A Note on the RE Lab

There are many other issues about regulations that affect RE installations. Many of these issues have a far greater impact on system cost than the banning of welding cable from battery boxes. The welding cable experiment was chosen as the first because it was relatively inexpensive. The RE Lab would like to address other issues that are important to RE system installers.

At present, the RE Lab is operating with no formal budget. We are looking for sources of funding, and for volunteers with grant writing skills. With adequate financial backing, we would perform a series of experiments dealing with other controversial areas of RE installation.

RE Lab volunteers would like to become involved in the code writing process. Our goal is to evolve clear guidelines—based on testing—that allow for safe, economical, and effective renewable energy installations.

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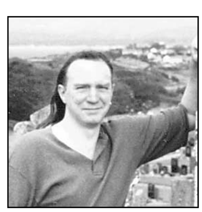

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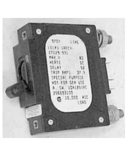

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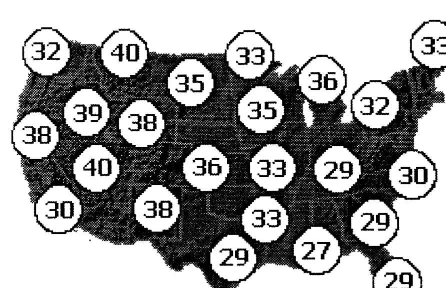

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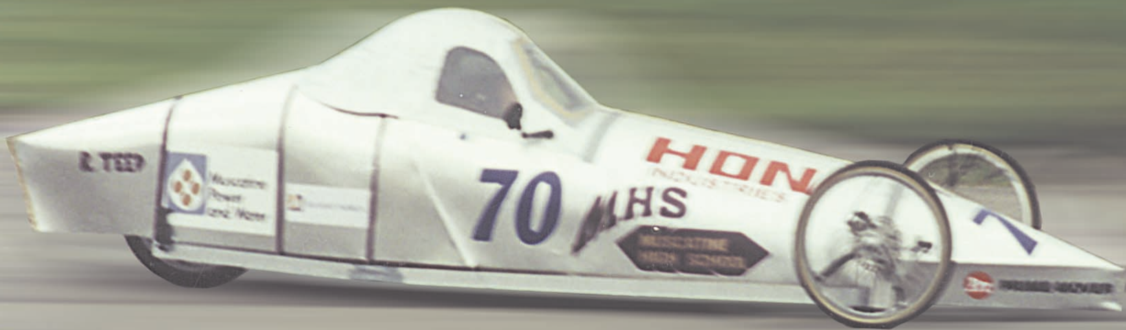
Muscatine High School Electrathon



Dan Gruemmer

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Randy Teed takes Muscatine High School's Electrathon car to the limit.

We had no idea what we were getting into, but we knew it was bound to turn out to be something great. This was Muscatine High School's first attempt at building an Electrathon car.

An Electrathon car is basically a go-cart that runs on batteries. You are allowed to use up to 64 pounds (29 kg) of batteries. There are many restrictions on the height, width, and length of the car that have to be met. The car can be no longer than 12 feet (3.6 m), and no wider than 4 feet (1.2 m). The car also has to have at least three wheels, and the driver must face feet first while riding in the car.

The Electrathon is an annual event held in many states all over the U.S. It is a race for distance, not time. The object is to see how far you can go in one hour. The cars are all started at the same time, and they race around the track while their laps are being counted. Each car runs in two out of the three heats (they have three heats total because there are so many participants). The best distance out of the two heats is the one that is taken, and the other is thrown out. The car that goes the farthest wins.

Mark Rhoads is an Industrial Arts teacher at Muscatine High School (MHS) in Muscatine, Iowa. He is also the main advisor behind the MHS Electrathon Project. He has had all of the members of the 2000 Electrathon team in his classes at some point. So all of us knew him, and that's how we learned about the Electrathon in the first place. Phil Fitzgerald, another Industrial Arts teacher at Muscatine High School, was another key advisor for the project.

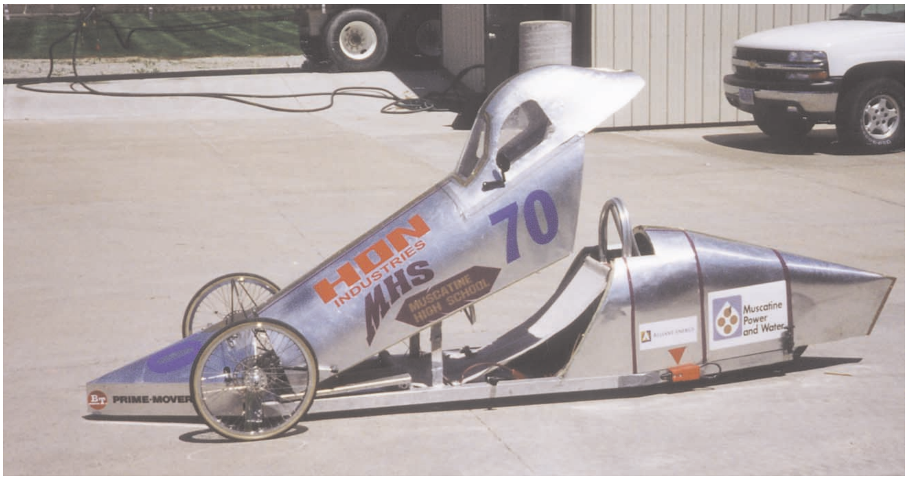
Mr. Rhoads and I had gotten some idea of what the Electrathon was by visiting the Iowa Electrathon the year before, and seeing some of the cars there. I knew I was excited about building a car that actually ran on batteries. Mr. Rhoads was probably a little hesitant about leading the project since he didn't know much more than I did about what went into making an Electrathon vehicle.

On top of that, we had no funding to make this car. Funding is a very important aspect of an Electrathon car. You need donations for parts and supplies to make a car like this. Ours cost about US$4,800 to build.

First Year

The first year of doing the Electrathon is always the most difficult. Our team heard this over and over from teams that had some experience. Although this worried us some, it definitely didn't slow us down. All a new

team really has to do to get the funds to make a car is get other people interested in the project. That may sound difficult, but believe me, when you are doing something as extraordinary as making a car that doesn't run on gasoline, it comes fairly easily.



Number 70 awaits a driver.

Our team was very fortunate for two reasons. We had a lot of community interest in our school's project. And we had a very decisive individual come our way at just the right time. John Root, former organizer of the Iowa Electrathon, had just moved to Muscatine to take a job as Energy Services Advisor for Muscatine Power & Water. Not only did he offer us his expertise, but he was also able to get his new employer to make a very generous donation to get our project started.

After getting enough funding for our project, the next step was to do some research and find out exactly what we needed to do in order to piece together our Electrathon car. There were a lot of parts that went into building the car that we didn't even know existed. But all it took was a little research and help from fellow Electrathon teams to get us started on the right foot.

Learning Curve

It's also becoming easier for new Electrathon teams to start up due to the information on the Internet. Even our team—in its first year—got a Web site up and running. Other teams have sites that give details on the design and construction of their cars. Our team actually did a majority of its research on the Net. We found information, sources for parts, and even purchased some parts online. We were also fortunate to get a list of parts from another Iowa Electrathon team.

As a team, we really only made one major mistake—we didn't budget our time as well as we should have. It's a common mistake with first year teams, but we did learn from it.

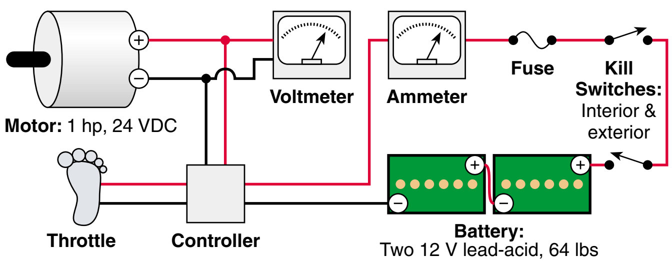
I would recommend that any new Electrathon team write out a brief calendar of goals, and when they hope to achieve them. The calendar doesn't have to be strict at all, but it will still help to keep the team focused on what they have to accomplish. There is plenty of time to build an Electrathon car within a year (including the time spent to gain exposure and get sponsors) if the team is willing to make the effort and do the necessary planning.

One thing our team did was to put a lot of effort into the project. Most of us worked on the car for about eight hours a day over spring break (although this was partially due to our initial lack of time budgeting). Over the average school week, the team probably spent about three hours per person on the project. As time started to run out later in the year, we each spent more like ten hours a week on the car. We were all dedicated and very involved in the project, which was a key factor in how well our car turned out.

A lot of the trouble we had with budgeting time was during the period of research and ordering parts for the

The local utility helped finance the project—hint, hint...

Electrathon System Wiring



car. It was easy to let time slip by then because the team members were unable to see what they were making. On the other hand, once the parts for the car arrived and construction began, everyone started getting really excited about what we were doing, and couldn't wait to do more.

To me, one of the neatest aspects of the entire project was seeing the car slowly coming together and become something that we could actually drive. But this process took a lot of work. There were a lot of different systems to the car that made it complicated to build.

Construction

The first system we constructed was the frame—an obvious place to start. The frame was built out of 2 inch (5 cm) aircraft aluminum, and was approximately 8 feet, 6 inches (2.6 m) in length, and 2 feet (0.6 m) in height. After the construction of the frame, we started positioning all the components of the car.

This was actually a lot more difficult than you might think, since there was a lot of engineering involved. Not only did we have to position these components to fit around our driver, we also had to position them to take up as little room as possible (generally speaking, the smaller the car is, the better). And we had to meet the fairly strict rules put in place by the Iowa Electrathon race committee.

After piecing together the basic elements of the car, we started in on the electrical system. We had to put some of it together after other things were installed, to see where we would and would not have room.

When building this car, the team members have to become experts in all of the systems of the vehicle. It is not like the construction of a building, where you have one group of people specializing in building the frame and exterior, another group doing the electrical and wiring job, and another group of people doing the plumbing. We had to do everything involved in the construction of the car. That's why it's good to have a well-rounded team.

Electrical, Steering, & Brakes

As for the electrical system, there was a great deal of wiring involved. Most of us started out knowing little about wiring. Fortunately, we received a lot of help from the community, and from our advisors. Good advisors make a good Electrathon team, and we had very good advisors helping us out.

The electrical system consisted of a 1 hp 24 V motor, two 12 V batteries, controller, throttle, ammeter, voltmeter, fuse, and two kill switches (for safety). After all that equipment wiring was completed, most of the team members could probably rewire the whole thing in their sleep! We all learned a lot about basic electrical concepts.

While the electrical components were being pieced together, we also started working on the steering and braking systems. These were by far the most expensive group of parts on the vehicle.

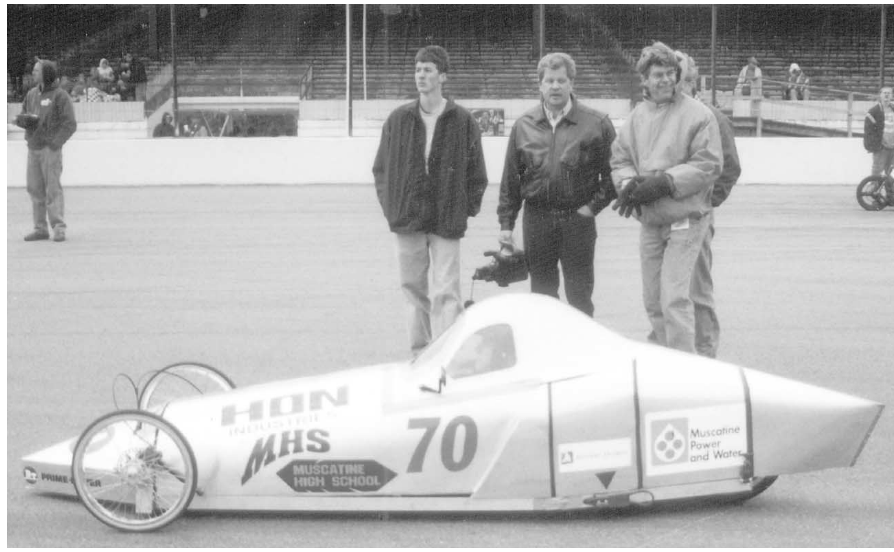
The three wheels that we had on our car (two wheels in front, and one drive wheel in back) were similar to bicycle wheels, but were custom made to be much stronger. We also had two disc brakes mounted on the car—one on each front wheel. Setting up the steering and braking on the two front wheels was probably one of the most time consuming portions of the construction of the car because it required precision work.

Our axles were set to swivel on an angled shaft to make the steering more efficient and cause less friction between the tires and the track. Setting up a complicated steering system isn't recommended for first year Electrathon teams, unless you are fairly knowledgeable on the subject to begin with. Fortunately, our team had some help with the steering setup from a fellow Iowa Electrathon team.

Muscatine High Electrathon Costs

Item	*Cost (US$)*
Wheels, tires, & brakes	$1,055
Motor, controller, & wire	600
Aluminum tubing	500
Batteries	480
Tools & miscellaneous	472
Body	450
Bearings & sprockets	400
Speedometer & miscellaneous	300
Decals	150
Helmet	120
Steering parts	120
Conduit	100
Ammeter	60
Total	$4,807

Car Body
The next (and basically, the final) section of the car was the outer shell, or body. This was one of the more technologically advanced pieces of the car that we worked on, though it doesn't have to be. Our body was designed by two of our team members using computer aided design (CAD). We then had the help of a local company (Hon Industries), which laser-cut the separate pieces for the subframe of the car.



Author Dan Gruemmer, his dad Randy, and Mr. Rhoads at the starting line.

This subframe was the basis of our outer shell, and was all made of aluminum—one of the lightest weight metals available to us. We were careful when we designed the body to make sure that there were no sudden changes in its curvature, since this would result in turbulence.

Aerodynamics does not play a major role in the race, because the average speed is only about 30 mph (48 kph). But it is a factor that any team hoping to win has to take into serious consideration. Fortunately for us, our car body followed the basic rules of aerodynamics—a pointed nose, smooth body, and tapered end. But the body of an Electrathon vehicle does not have to be anything complex. Many cars simply have pieces of plastic glued onto the frame to help deflect air, and some cars have no outer shell at all.

Testing
After we had completed the body of our car, we were ready for testing. We had two pairs of batteries, partially to help us in testing, and also because we had to race in two consecutive heats at the Electrathon race. We could be running one set of batteries while we were testing, and at the same time be charging the other set of batteries. The batteries can run for over an hour in our vehicle if the energy is somewhat conserved. The time they take to charge depends on the charger and amperage, but it's usually around four to six hours.

Because it was our first year, we didn't get into testing too extensively. Mainly what we tested for were any mechanical or electrical problems that the car might have. We also tested to see what amperage would get the most out of our batteries during the race. Ideally we wanted to run out of battery power just after we crossed the finish line, but this is very hard to do.

Unlike most auto races, the Electrathon isn't all about speed, it is about efficiency. The idea of the Electrathon is to go as far as you can in one hour. Obviously, you have to maintain a decent speed in order to win the race, but the vehicle also must run efficiently enough to go for the whole hour that the race lasts.

After completing the car body, we added the sponsor and design logos. Most of our sponsors were happy to supply us with sticker logos to put on the sides of the car. But for those who didn't have any available, we had some made along with our own Muscatine High School logo. They turned out looking great on the silvery aluminum background.

Off to the Races
Not long after everything was completed on the car, it was time to head to Hawkeye Downs in Cedar Rapids for the race. When we got there, we found that the conditions weren't that great, but at least we knew everyone had to deal with the same thing. It was cold (which makes the batteries not perform at their best), and it was windy (which makes handling more difficult).

Every car races in two out of the three heats at the race, and our car was to race in the first two. The first heat went well, and the car had no mechanical or electrical difficulties at all. We ended up getting 59 laps, which comes out to just under 30 mph!

In the second heat, we had several setbacks. Most of these setbacks were simply from lack of testing. The first problem we had in the second heat came at the start of the race. The green flag was waved, and all of the cars started rolling ahead—except ours. It turned out we just had a loose connection in one of our wires. We quickly fixed it and got ourselves back in the race.

Then about halfway through the race, our driver, Randy Teed, told us over the radio that the car was getting

really hard to control in the corners. He suspected it might just be due to the fact that it was very windy outside. After a few more minutes he came back on the radio and said that he was beginning to think that it wasn't just the wind and thought he should stop in the pits so we could check it out. Sure enough, the rear tire had blown out. We were very fortunate that he didn't spin out, because that is a common problem of Electrathon cars when they get a flat tire.

So the team had to take off the tire, remove the tread, and take off the old tube before we could put on the new tube and air it up. This process took up a lot of time that we could have been out on the track racing. Needless to say, we lost quite a few laps because of this. After the second heat was over, we ended up having about 15 fewer laps than we did in the previous heat. But considering all of the problems we had in the second heat, that wasn't too bad.

Fine Finish

There are many teams in the Iowa Electrathon who have had years of experience and have actually had time to do all of the testing they want to. But our first year Electrathon team ranked well among all of the competitors. We finished in the top fifteen out of thirty-something cars. And we managed to finish ahead of all but one of the many first year teams racing that day.

The team is very confident that it will be able to do even better at next year's race. We now have the experience and knowledge of what it takes to create a top-notch Electrathon vehicle. We will be building at least one brand new car to race (along with the original car) at next year's Iowa Electrathon.

The team's popularity also looks very promising. There was a lot of interest built up from the 2000 Electrathon. Many of the students at Muscatine High School were able to see the final product that our Electrathon team was creating. It is much easier to gain people's interest when they can actually see what an Electrathon car is.

Being a member of my high school's Electrathon team, and especially being the first team at the high school, was an excellent experience. I learned a great deal about a broad range of subjects while building the Electrathon car, not to mention all of the fun I had working with my teammates.

Besides all of the positive educational aspects of the Electrathon project, it is also helping to promote energy efficiency and environmental awareness. I would highly recommend this project to anyone who is interested in trying new things and likes to put creativity and ingenuity to excellent use.

Access

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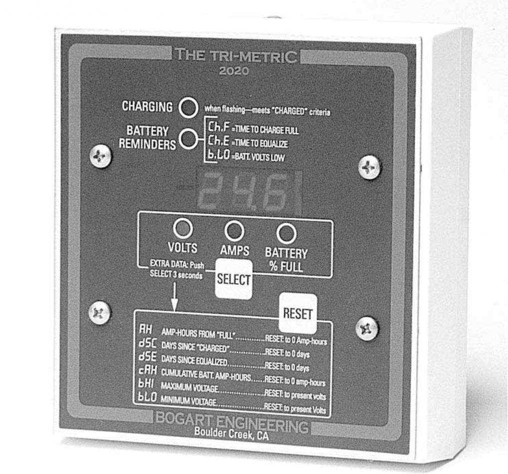

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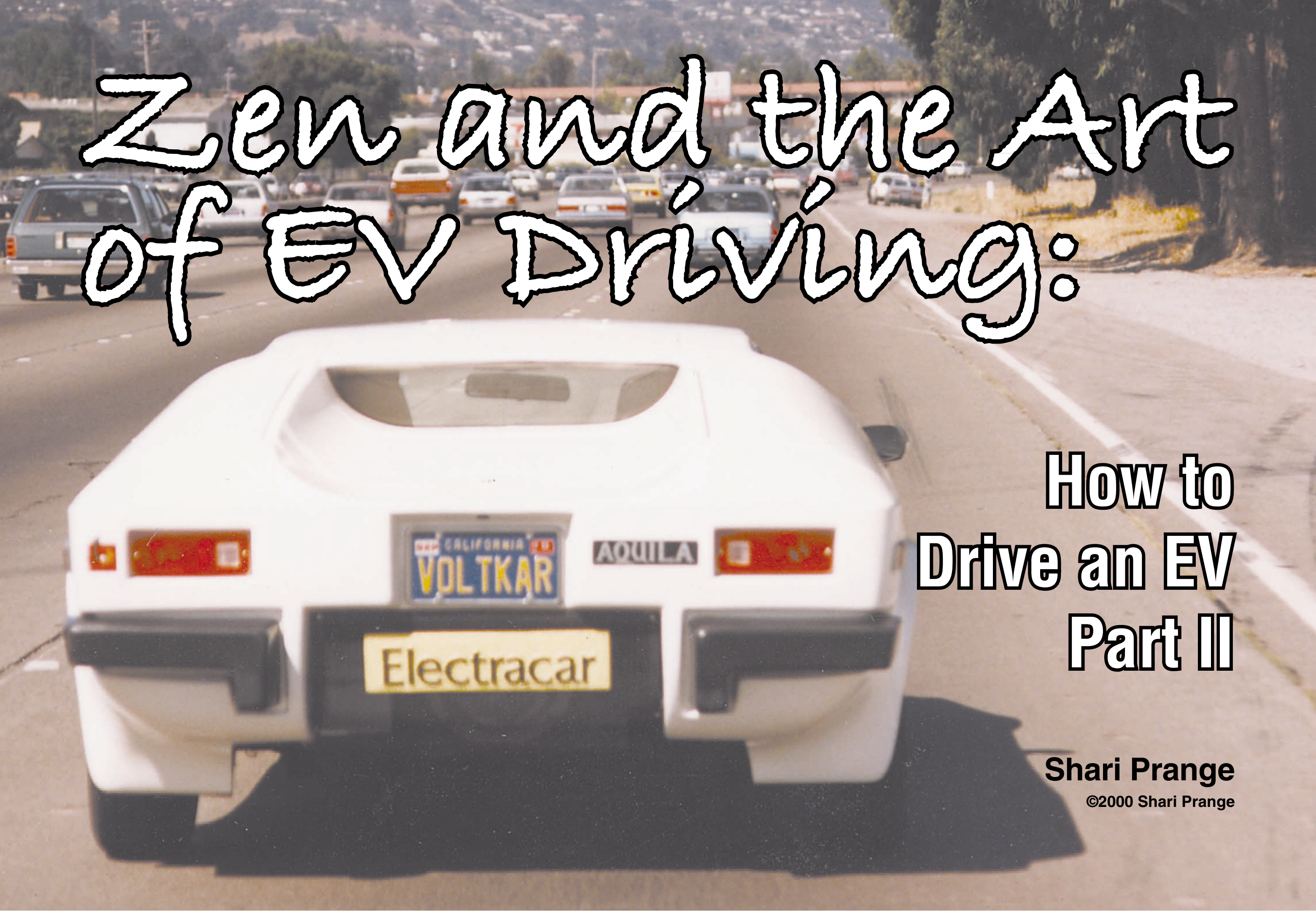
Zen and the Art of EV Driving:

How to Drive an EV Part II



Shari Prange

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Last issue, I got you into your electric car, and you turned the key and pulled out of the driveway onto the street. You learned when to shift gears, and how to find the "sweet spot" for the most efficient driving. I introduced the idea that sometimes you make better progress when you relax and don't push as hard, which is some of the Zen of EV driving. Then I left you circling the block for the past two months while you waited for the next lesson.

Now that you've had lots of practice on the basics, let's move on to more advanced material.

Hills

Climbing hills in EVs is different from doing it in a gas car, both going uphill and coming down. In a gas car, as you start to climb a hill, you need to shift down to get more power. The same thing happens in an EV, but you need to shift down much sooner. This is something you will learn by experience. After driving up a few hills, you will get the feel for when to shift down to get the power you need.

This is another place where automatic transmissions fall short. They won't shift down soon enough, and will leave you laboring uphill with not enough power.

Then there's the downhill. Since conversions don't usually have regenerative braking, the car freewheels and gains speed going downhill. This can be both good and bad.

One bad part is that the car can easily exceed redline and destroy the motor by overspeeding it. Say you climb up a hill in second gear, and then you start to coast down the other side. Very soon, you're doing 50 mph (80 kph) or more, which is too much for second gear. In a gas car, you would shift down to slow the car down. In an EV, that will only destroy the motor. Instead, you need to shift up to protect the motor.

You control your downhill speed with your brakes. This is why it's a good idea to have power assisted brakes, and to use the beefiest metallic shoes and pads you can get for your car. For some models, there are fairly

simple upgrades from drum to disk brakes, or to larger disk brakes, and these are a good idea.

It's also a good idea to brake with periodic pulses, not steady braking. Continuous braking for several minutes can overheat your brakes, especially since the conversion is heavier than it was as a gas car. If you have hills on your regular route, you need to approach them cautiously the first few times, until you see how the car handles them. With a little practice, you can learn the most effective places to use your brakes for a few seconds.

Incidentally, this can be a problem even for cars that do have regenerative braking. Many people live high and work low. Their big downhill comes when they first leave home, with a fully charged battery pack. With no place for the motor to put the electricity it can generate, regen doesn't work.

Now the good part about hills. When you top the crest and start down, take your foot off the throttle. You don't need any juice. Coast, and let gravity do the work. If you drive through hilly areas where traffic is light and flows freely, you can learn to use your downhill momentum from one hill to carry you up the next one. You will be amazed at how far it can take you. I have a stretch where I can coast for four miles without touching the throttle, make a ninety degree turn, and coast another several blocks, right into a parking space at the post office.

Some drivers of factory EVs, such as the GM EV1 or Honda EV Plus, regret the fact that they don't have the choice to freewheel. In those cars, regenerative braking automatically kicks in when you lift your foot off the throttle, just like engine braking in a gas car with a manual transmission. This slows the car down, which can be good if you want to control your downhill speed without using the brakes. But it robs you of the choice to take advantage of your downhill momentum.

Freewheeling and using the car's momentum to coast actually saves more energy than regenerative braking recaptures, because there are slight inefficiencies and losses in the regen system. For this reason, some drivers of these cars put them into neutral on downhills, to disable regen and opt for freewheel coasting instead.

Highways

Most conversions with at least 96 volt systems can achieve highway speeds. This type of driving can actually be very efficient if you find the "sweet spot" we talked about last time and cruise steadily.

Third gear will generally handle speeds up to about 65 mph (105 kph), and fourth gear is probably good up to about 85 mph (137 kph). As we talked about last time, your best efficiency is at the top of the rpm band for a particular gear. If you are cruising at 60 mph (97 kph), you will be more efficient in third gear than in fourth. Higher gears can give you more speed. Just be aware that it is probably costing you amps, and therefore range.

You may want to pass some of those pokey gas cars that are slowing you down (even sometimes on an uphill!). In a gas car, you may downshift for more power for passing. In an EV, you have to be careful about this. If you downshift at too high a speed, you will exceed the rpm limit of the lower gear, and grenade your motor. This is very embarrassing, and expensive. Learn the speed ranges for each gear until they become second nature to you, and stay within them.

The power band on the electric motor is different from that of a gas engine. The best way to learn this is by experimenting. Get on the highway where there isn't much traffic, and play with the gears. You'll soon get the feel for where to find your best acceleration for passing at various speeds.

And Byways

We talked earlier about driving on hills. But what if you're not just tackling hills, but driving up gravelly, unpaved hills, or even going cross-country? EVs aren't really meant for this type of driving, and it will reduce your range quite a bit. Anything that reduces traction interferes with efficiency.

That said, if you're going to drive offroad, here are a few things to think about. Experiment cautiously until you know what your car can do. You don't want the embarrassment of having to be rescued.

Protect your components. A little road splash won't hurt things, but you don't want major amounts of water or mud in your motor or on your electrical connections. And rocks can really spoil your fun. If you're going to be driving in these kinds of places, install some bellypanning and terminal covers to protect the motor and electrical connections.

Be sure that your protective measures still allow necessary cooling airflow to your components. This might mean carefully placed air intake and exhaust openings. The outflow opening should be larger than the intake, and should be placed at a natural negative air pressure point. This is so that the normal flow of air around the opening will draw the air inside out. You may want to completely enclose the air intake end of your motor and cool it with forced air through a filter.

Don't ford streams. To paraphrase the old anti-war poster, water is bad for motors and other electrical things. In addition to protecting yourself and your car,

protect the environment you drive through as well. Some components are likely to get hotter than normal if you are stressing them with heavy duty work. If these components brush against tall dry grass, they can start a fire, just as a gas car's hot exhaust system might do.

Strategies
EVs typically get used for the same jobs over and over, day after day. You probably drive to work and back, to the grocery store, to the bank, etc. You have the opportunity to plan which route to take for each of these normal errands. Sometimes you can significantly improve your performance with a slight change of route to avoid a particularly bad hill, stop-and-go traffic, or extra stop signs or lights.

Even if you can't avoid some of these things, there are different ways to deal with them. We've already talked about hills. Stop-and-go traffic is also bad for range. Every time you touch the brakes, you are wasting momentum that you paid for with amps.

Heavy traffic frequently moves in pulses. You speed up a little, catch up to the car in front of you, hit the brakes, wait for the next guy to move, speed up again, etc. It never actually stops, but it moves forward in spurts. Often, if you watch the traffic several cars ahead of you, you can find a steady pace that allows you to keep up with the flow of traffic without touching your brakes.

The car ahead pulls away from you a length or two. Don't speed up; let him go. In a minute, he'll tap his brakes, and you'll catch up to him. About the time you catch up, he'll speed up again. In the midst of everyone else doing stop-and-go, you're progressing smoothly and steadily—and efficiently. More EV Zen.

Handling & Pedestrians
Drive cautiously until you get used to the car. It can be deceptive if you are used to driving it in its gas form. It feels like the same car when you sit in the driver's seat. But it is heavier than it was before, the balance may have changed somewhat, and its power curve is different. It will corner differently (sometimes better), and it will accelerate and brake differently. If you try to drive it with your old gas car reflexes, you could get into trouble.

You will also need to be more aware of pedestrians, bicycles, skateboarders, and animals. They won't hear you coming, and may move right in front of you, or wait too long to get out of the way. This is especially true when backing out of a space in a parking lot. For this reason, some EV drivers install back-up warning beepers and deer warning devices on their cars.

Stopping
Okay, you've been driving around for quite a while now. Let's learn about stopping. In a gas car, most people stay on the throttle up to the moment they switch to the brake. As soon as you lift off the throttle, the car will start to slow down. This isn't true in an EV.

If you see a light turning red a block away, lift off the throttle now. The car will continue to keep up with traffic, and will only gradually slow down. If you have low rolling resistance tires, this process can be very gradual. With a little practice, you can time it so that the car has nearly stopped by the time you reach the light. Use your accumulated momentum—don't waste it.

When you do stop, you don't need to put in the clutch as you would with a gas car, since you can't kill the motor. You can simply depress the brake and stop, and the motor stops, too. Unlike a gas engine, it doesn't need to keep idling at stop, so it isn't wasting energy.

This is another problem with automatic transmissions. They depend on an idling engine to keep the fluid pressure up. Without it, there is a dangerous delay between the time the light changes to green and you step on the throttle and when the transmission actually engages and moves the car forward. In the meantime, the SUV behind you has rear-ended you, or the driver is leaning on the horn.

If you do put the clutch in when you brake to a stop, you need to keep it in until the motor stops spinning. The motor can easily take a full minute to run down to a stop if it is disengaged and freewheeling. If you let the clutch out before the motor stops spinning, it will try to move the car, causing an embarrassing lurch before it gives up. This is unpleasant for both the driver and the motor.

Remember to use your parking brake! Leaving the car in gear will not keep it from rolling away. I know of one EV that had low rolling resistance tires and was so light that a breeze would send it across a flat parking lot.

When Empty Isn't Empty
Here's the driving question everyone asks about EVs: What happens when I run out of juice? If you do things right, this shouldn't happen. After you have driven it for a little while, you'll know just about what your range is. These cars are typically driven on the same routes day after day, so there shouldn't be any surprises. The car should have some kind of voltmeter or state-of-charge gauge to let you monitor your battery pack status.

But let's say the unthinkable occurs. You have to make a surprise detour on the way home, or you have a slow leak in a tire, which creates drag and reduces your range. As you get to the bottom of the usable charge in

the pack, the car will gradually lose speed, especially on any upgrade. It doesn't happen all at once like a gas car running out of gas. You have some warning, and can travel at a reduced speed to a safe place to pull over.

Then some magic happens. If you park the car for ten minutes and let the batteries rest, they will "recover" some of their lost charge. This is also called "growing amps." You can watch your voltmeter needle climb. You can then drive a little farther. If necessary, you can rest the batteries several times to make it home. Stop, meditate peacefully for a few minutes, and both you and your batteries will be refreshed.

Bonus Miles

It really doesn't take much effort to learn a few simple tricks to maximize your EV's performance. It can be a game you play, where you try to find the most efficient technique for each stretch of road, and keep the ammeter needle as low as possible. The techniques can quickly become habits that you don't even think about.

The bonus is that when you get into a gas car, your EV driving habits will carry over. The same techniques that make for great range in an EV will make for great gas mileage in a gas car. There's just one habit you don't want to carry over—passing by gas stations. The gas car won't magically refuel itself in the driveway overnight, so you'll have to remember to fill it up.

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Battery Box & Battery Box Holddown Design

Mike Brown

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Last issue we talked about the design and fabrication of battery racks and how to secure them to the car. This issue we will talk about the kinds of coatings used to protect the racks from the elements and any stray battery acid. Once we have that covered, we'll look at battery box design, materials, construction, and ventilation. Then we'll wrap it all up with a discussion of the battery box holddowns. These are the parts that hold the battery box, batteries, and battery box lid to the battery rack, which is attached to the chassis of the car or truck.

Paint Your Wagon

So now you have your new battery racks fresh from the welder, but they are bare metal. What do you do to protect them from the elements and possible contact with battery acid? First, have them sandblasted. Sandblasting removes any surface rust that might have started to form. It also removes the thin coat of mill slag, which is a byproduct of the steel mill process that forms the steel into the angle, flat, and channel stock we used to build the racks.

Once the racks are cleaned down to real bare metal, they should be washed with hot soapy water and thoroughly dried. When they are dry, they should be immediately sprayed with epoxy-based primer paint. After the primer is dry, the epoxy-based topcoat paint in the color of your choice can be applied. The reason for the emphasis on epoxy primer and paint is that epoxy-based paints are the most resistant to battery acid.

You can do all the painting yourself with rental equipment, or have a local autobody shop do it. The sandblasting should be left to a professional because of the equipment involved and the mess it makes, which leaves sand in everything, forever.

Another coating process that can be used is powder coating. Like paints, powder coating comes in different grades, and I again recommend the epoxy version. This process also starts with sandblasting. Then the parts are hung on racks and the dry epoxy-based powder is applied by the electrostatic attraction process. In this process, the part is given a negative charge and the powder is given a positive charge. As the powder leaves the compressed air powered gun, it is attracted to the part and flows around it, inside corners, and into hidden areas.

After the parts are coated, they and the rack holding them are placed in an oven and baked at 375 to 400°F (191–204°C) for a suitable amount of time to cure the powder and fusion-bond it to the part. This process results in a finish that is tougher, more durable, and more chip resistant than conventional spraypaint. The epoxy powder-coated part is resistant to battery acid, and the coating acts as an electrical insulator, two features that are helpful in an EV.

We have the battery racks for our Voltsrabbit and Voltsporsche kits powder coated. In addition to the above benefits, it also holds up better during shipping and is cheaper than conventional painting. There is an additional environmental benefit—the powder coating process does not release any volatile solvents into the atmosphere. If you can find a company in your area that does powder coating, you should give serious thought to having your racks powder coated.

Thinking Inside The Box

Now let's take a look at battery boxes. The main purpose of the battery box is protection. It contains the batteries in one place and protects us from the batteries' chemical and electrical dangers. The battery box also protects the batteries from the elements and accidental short circuits caused by mishap or carelessness.

A sealed and ventilated battery box is required any time batteries are placed in the passenger compartment of

the car. This applies to batteries placed in the trunk if the box is not separated from the passenger area by a steel firewall. In fact, the only place it is permissible to put batteries in open racks with holddowns is in the former engine compartment, which the factory takes great pains to seal off from the passenger compartment. Even in a pickup truck conversion, where some of the batteries are placed under the bed, these batteries should be in boxes for protection against dirt and possible damage by road debris.

So, given their heavy responsibility, some careful thought should be devoted to battery box design, the material used, and how the boxes are constructed.

A lot of the design work on the battery boxes has already been done when the racks were designed. The size and shape of the box was determined when we did the original battery layouts. The choice of material was made because the thickness of the box walls determined the dimensions of the rack that holds the box.

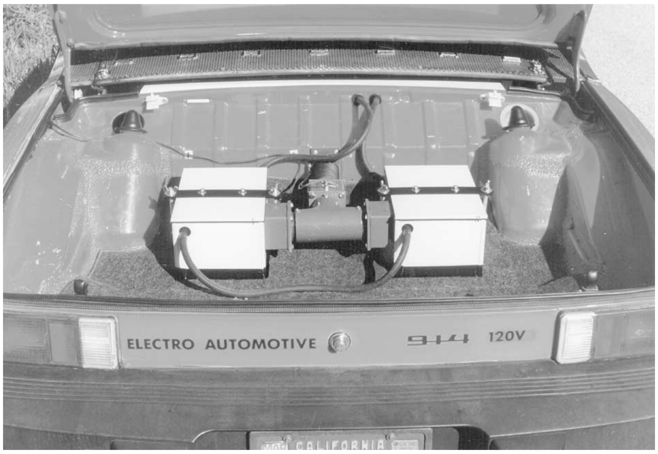
Cable Ready
One of the design tasks remaining is deciding where the cables that connect the batteries to each other, and to the other drive components, are going to enter and exit the boxes. The goal here is to connect the batteries in each box in series, connect the boxes into a series string, and finally connect the most positive and most negative terminals of the battery pack to the controller, all with the shortest possible lengths of cable.

This is accomplished by orienting the batteries in the box so that the positive post of one battery can be easily connected to the negative post of the next battery in the series. Depending on where in the box you start the string, you will end up with one battery with a bare positive terminal and one battery with a bare negative terminal. The trick is to arrange the batteries in the box in such a way that bare terminals are on the side of the box that you want the cables to enter.

I have a sheet of scale drawings of the batteries we use that can be cut out and used to help you lay out your battery pack. Copies are available for the asking. Once you've found the arrangement you want, mark the location of the cable holes on your battery box plans.

Good Air In, Bad Air Out
The passenger compartment battery boxes have to be ventilated to the outside of the car. So part of the battery box design is the location of the air inlet and exhaust ports, and the location of the fan that provides air flow to the system.

Before we get into the nuts and bolts of battery box ventilation, let's discuss the reason for it. Lead-acid



Grey PVC pipe provides fittings for forced air ventilation of boxes during charging.

batteries give off hydrogen gas when being charged and discharged. More hydrogen is given off during charging because the batteries are intentionally gassed. This is done to equalize the charges of the individual batteries at the end of the charging cycle.

During discharge, much less hydrogen is given off, and then only when heavy demand is placed on the batteries when they are already almost fully discharged. When four percent of the atmosphere in a closed space is hydrogen, you have an explosive mixture. The mission of the battery box ventilation system is to prevent that much hydrogen from gathering in a sealed battery box, or leaking into the passenger space of the car.

There are two types of battery box ventilation systems: the sealed box/pressure fan system, and the unsealed box/suction fan system. The sealed box/pressure fan system is the system used when there is a battery box in the passenger compartment, or where the trunk is not sealed off from the passenger compartment by a steel firewall. The battery box is airtight except for an inlet port with a fan in it that draws air from the outside of the car, and an exhaust port that is connected by a duct hose to an exhaust vent that is open to the outside of the car.

When the battery charger is plugged in, the fan comes on and blows fresh air across the tops of the batteries and out through the exhaust system to the outside of the car. Since the fan comes on at the very start of charging, it blows away any hydrogen produced while sitting after driving. The constant flow of air across the batteries does not allow any buildup during charging. If the exhaust vent outlet is placed in the airflow under the car and perpendicular to the airflow, suction called "road draft" will build up in the exhaust port, and will pull

any hydrogen produced during driving out of the battery box.

The unsealed box/suction fan system is used on battery boxes that are under the hood, under the bed of a pickup truck, or in a sealed trunk. With this system, when the fan in the exhaust port comes on with the charger, outside air is drawn through several small inlet ports on the opposite side of the battery box, across the batteries, into the exhaust port, through the fan, and out into the outside air. Any hydrogen produced during driving exits through the inlet holes.

If this system is used in a sealed trunk, air should be allowed into the trunk in some way that doesn't allow dirt or water in. This is especially true if the battery charger is in the trunk, and is also drawing its cooling air from the inside of the trunk. The exhaust outlet should be positioned in a place where it can take advantage of the road draft effect.

We use both brushless DC and AC fans depending on the type of ventilation system and the number of fans needed. Underground sprinkler supply stores, with their large stock of PVC pipe and fittings, are a good source of supply for the inlet and exhaust parts needed. Specialty hose shops can supply the hoses you might need to hook things together. Marine supply stores are another good source for these kinds of parts.

The location of the intake and exhaust ports and fans on the battery boxes, as well as any fresh air intakes and exhaust outlets on the car's body, should be determined at this time.

The Hole Thing

Getting back to battery box design, let's discuss the size and shape of the ventilation ports that have to be cut in the side of the battery box. Since space considerations always seem to dictate the shortest possible battery boxes, the distance between the top of the battery and the battery box lid averages about 1-3/4 inches (4.4 cm). Cut a rectangular port in the side of the box, using as much of the space above the batteries as you can for the height of the port. Use the diameter of the fan blade as the length of the port.

When mounting the fan, do not just bolt it to the side of the box with part of the fan covered by the box and part blowing through the port. The differences in the airflow between covered and open sides of the fan blades would put excessive strain on the fan bearings, and cause early failure.

If you can't get a wide enough hole in the box, you can get around this problem by mounting the fan on a one inch (25 mm) spacer tube big enough to match the diameter of the fan blades. You can then mount this assembly to the box. The spacer tube provides a space that allows the airflow to smooth out before it enters the port in the side of the box.

If the fan has to be connected by a hose to a fitting that goes to the outside of the passenger compartment, build a housing that has this smoothing space on one side of the fan and a flange to attach the hose to on the other side. The locations of the ports and any mounting holes for fans or hose flanges should be drawn on your battery box plans.

Wooden You Know

In the first part of this series of articles, I suggested that you start your battery rack design with the thickest battery box material. This gives you the worst case largest dimensions for your proposed battery box/battery rack assembly. If you do that and find that using a thinner material will allow you to install the required number of batteries in the desired location, you have that option.

Now we'll take a look at some popular battery box materials and the methods used to construct battery boxes from them.

Following the advice given above, let's start with the thickest material that has been used for battery boxes, which is plywood. Plywood has the advantages of being cheap, widely available, and easy to work with, using a minimum of special tools. Its disadvantages are the thickness necessary to provide the required strength for a safe battery box, the weight that comes with the thickness, and the need for reinforcement of the box to further strengthen it. A minor disadvantage is lack of acid resistance, which can be eliminated with the application of our old friend, epoxy paint.

The plywood to be used should be "good-on-one-side" grade 5/8 inch (16 mm) thick. If you have a space problem, 1/2 inch (13 mm) is the absolute minimum. Care should be taken to make all cuts straight and all angles true for ease of assembly. A well set up table saw with a plywood cutting blade is helpful here.

All ventilation holes should be cut into the sides of the box as necessary before the box is assembled. The boxes are assembled using a combination of stainless steel grabber screws for corrosion resistance, and structural adhesive for added strength. Box construction is speeded up if you use one electric drill for pilot holes and another drill to install the screws.

If the box is to be used in a suspension rack, no additional reinforcement is needed. However, if it is being used in a bridge or floor rack, the box should be reinforced. If the box is a rectangle, a good way to do that is to have a local moving and shipping company

apply steel banding at two levels around the sides of the box.

If the box has an irregular shape, you should reinforce the corners, which are the weakest part of the box, with aluminum angle stock or steel angle brackets. When it is all finished, paint it inside and out with epoxy paint. A box I made this way served as a battery box for ten years before the car was scrapped, and is now in use as a lockbox for UPS deliveries.

Fun With Fiberglass

Battery boxes have been made of fiberglass cloth and epoxy resin, which is somewhat lighter and stronger than plywood. The problem with this method is the necessity to build a mold to lay up the cloth and resin on or in. This is a lot of work for a one-off piece. If you are experienced in fiberglass work and comfortable with the amount of work involved, it is a good material to use, and makes attractive boxes.

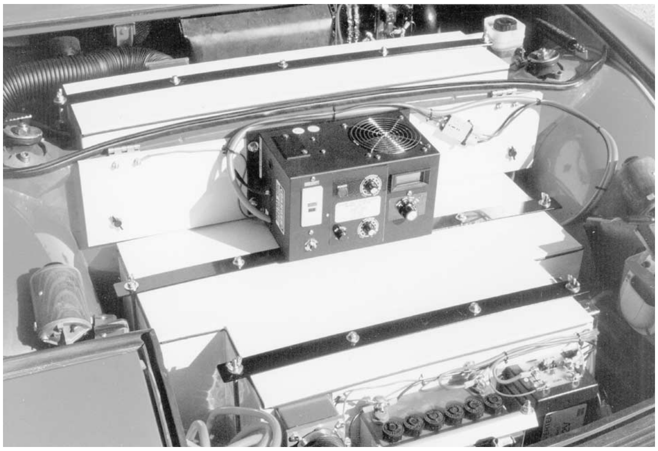
One Word: Plastics

The next material is 1/4 inch (6 mm) polypropylene sheet, which is thin, lightweight, not harmed by battery acid, and doesn't need painting. However, like a plywood box, it needs a rack to reinforce it. If it will be used with a bridge or floor, this will have to be taken into consideration in the rack design.

A polypropylene box is constructed by clamping the pieces of the box in place and then welding the seams together with a hot air welding gun and polypropylene rod. The special tools involved and the skill level required to achieve good results make the job of fabricating polypropylene battery boxes one best left to a professional.

I feel that, despite the need for a more complex rack and professional fabrication, the welded polypropylene battery box still has advantages. It is acid resistant and attractive, like the fiberglass box. But there is no need to build a mold in order to fabricate it. A polypropylene box is thinner, lighter, and stronger than a plywood box, and doesn't need to be painted to protect it from battery acid.

Polypropylene boxes look attractive.
Steel straps secure the boxes to the racks below.



If a polypropylene battery box appeals to you, look in the Yellow Pages under the "Plastic Fabricators" heading to see if there is somebody in your area who does polypropylene fabricating.

Full Metal Jacket

The last box material we are going to talk about is metal, specifically, aluminum or steel. A metal box is the most expensive type of box to have fabricated. The reasons are the number of special tools required, such as sheetmetal breaks, cutting shears, and welders, and the skilled workers necessary to operate them.

The metal box offers the strongest box for the least weight and thickness of any material. One of the other advantages of the steel box is that it can be used like a suspension rack and welded into the hole in the body, eliminating the battery rack itself. An aluminum battery box would have to be bolted to the chassis but could use a simpler, lighter version of a bridge or floor rack system.

Randy Holmquist of Canadian EVs uses metal boxes on his Metro and Chevy S-10 kits, and is very happy with them. Metal boxes are very susceptible to corrosion so they should be painted inside and out with epoxy paint. Randy uses spray-in truck bed liner on the insides of his boxes and reports good results. If space considerations force you to use a thin battery box, and the fabrication expense is not prohibitive, a metal box is a good way to go.

Know When To Hold 'Em

So far in this series of articles, we have built battery racks and secured them to the chassis, built battery boxes and installed them in their racks. The last item to consider is how to hold these boxes filled with batteries in place. Since the batteries are held in place by the sides and floor of the box, the only movement left to consider is the slight up and down movement caused by bumps in the road, and the catastrophic movement caused by a crash or in the worst case, a rollover.

The place to start talking about battery box holddowns is the battery box lid. On plywood and metal boxes, the lid is made of the same thickness material as the sides of the box. The lid of a polypropylene box is made of 1/2 inch (13 mm) material. Provision should be made in the lids for a weatherstrip-type seal between the lid and the top of the box.

The tubes on the lid of this box press down to hold the batteries firmly in place.

To make the lid part of the holddown system, spacers sized to fit between the battery tops and the lid bottom should be fastened to the lid. These spacers should be made of the same material as the lid and should be screwed or welded to the lid. Place the spacers where they can contact as many corners of the batteries as possible without interfering with the battery interconnects or other cables.

The job of holding the battery box, batteries, and lid to the battery rack is done with 2 inch wide by 1/8 inch thick (50 x 3 mm) straps positioned over the rows of spacers on top of the lid. They can be oriented front-to-rear or side-to-side, whichever is most convenient. Use as many straps as you have rows of spacers.

The straps can be fastened to the lids with screws or double-backed tape if desired. The important thing is that they are fastened to the rack below. We weld Grade 8, 3/8 inch (9 mm) bolts to the racks and use matching wing nuts and washers to hold the straps to the racks.

To Make A Long Story Short

As long as this series has been, I have only skimmed the surface of the subject. If you have any specific questions about battery containment systems, write or email me and I'll try to help.

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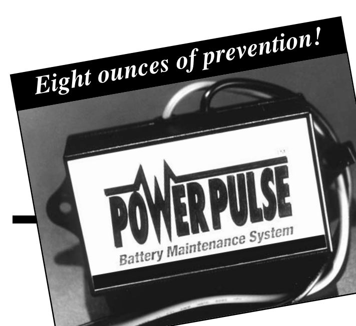

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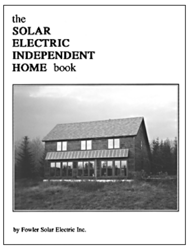

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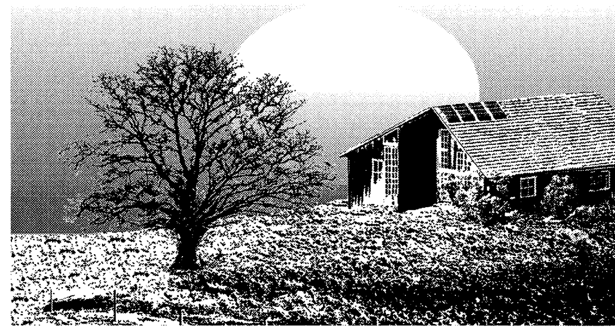

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Renewable Energy Terms

Renewable

Not "Alternative," and Certainly Not "Alternate"

Ian Woofenden ©2000 Ian Woofenden

Derivation:* RE- *Middle English from Old French from Latin: again, anew.* NEW *Middle English "newe" from Old English "niwe" or "neowe": recent, fresh, rejuvenated, additional.* -ABLE *Middle English from Old French from Latin "-abilus": susceptible, capable, or worthy of a specified action.

When I was younger and saucier, I teased my now co-worker Michael Welch about his use of the term "renewable." "Coal and nuclear power are renewable," I said, "they just take longer to renew!"

Well, with that sort of logic, I suppose I could have gone into politics. But the key thing is that solar, wind, and hydroelectric energy are *immediately* renewable, while coal, oil, and uranium take millions of years to develop.

Most energy forms find their origins in the sun. The sun drives the hydrological cycle, evaporating water from the oceans and dumping it in the mountains so it can flow down to the sea again, driving our hydro turbines on the way. The sun's heat also makes the wind, heating some areas more than others and making high and low pressure areas that create winds.

For years, the technologies that attempt to capture this natural energy have been called "alternative energy." But hanging onto this label hobbles our renewable horse before it leaves the gate. "Alternative" means something abnormal—something outside existing institutions or systems. That's not what we want for renewables, so why use this label? We want renewable energy to be the norm, not something outside the norm. Besides, human use of wind and solar energy pre-dates the use of fossil fuels by many thousands of years. In the perspective of human life on our planet, fossil fuels are a less conventional alternative.

By using a positive and descriptive label—renewable energy—we tell people why we are excited about these technologies. We also raise a not so subtle question—are other technologies *not* renewable? When you harvest some sunshine with your PVs, or some wind energy with your turbine, more sunshine and wind will follow it the next day. When you mine coal, oil, or uranium, you use something that is, for all practical purposes, irreplaceable.

Some people have been known to use the phrase "alternate energy" to describe solar technologies. Some even use it as part of their business names. This is unfortunate, since it's not the proper use of the word.

"Alternate" means changing back and forth, taking turns, or every other one. It also means a stand-in or substitute. We see it used to describe "alternating current," among other things. But I now hear it used as a synonym for "alternative" quite often. At some point, word purists have to let go and let the language change, even through misuse. But it still makes me wince to hear it.

The phrase "renewable energy" is becoming more common, and that's all for the good. It is a positive and clear statement of what we are working toward. It means energy that comes not from finite resources that can be exhausted, but from sources that continue to provide clean energy day after day and year after year.

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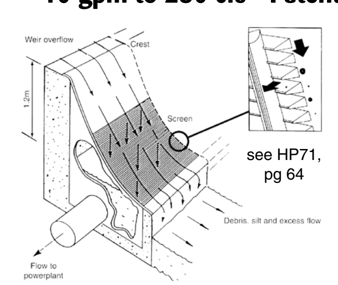

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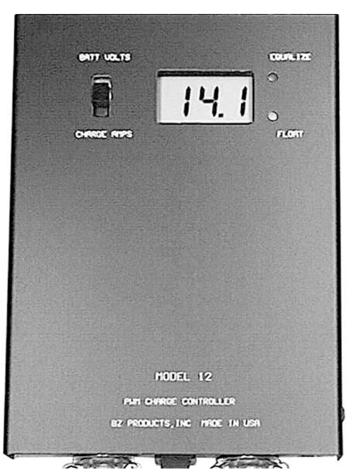

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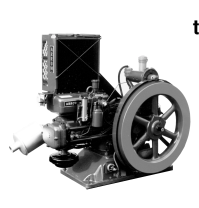

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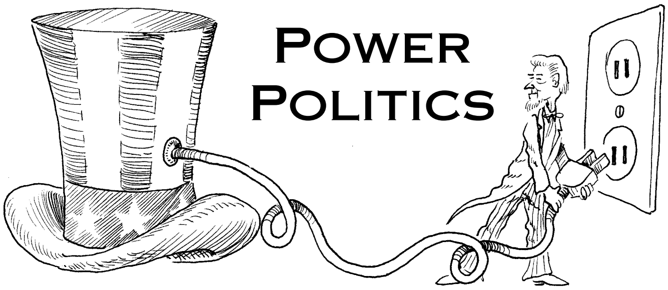

Skyrocketing Energy Prices

Michael Welch

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Are you feeling like you're being taken to the cleaners by high energy prices? Hey, it's not just a feeling, you definitely are being ripped off.

This year has seen the some of the highest prices ever for fuel and electricity. What's behind it? Both greed and corporate manipulation. But some folks think that high prices are good because it will help foment revolution to regain control of our government and society.

Electricity Prices Double & Triple

I live in California, one of the hardest hit states in this energy crisis. California went through utility "restructuring" a few years ago. As reported in past *Power Politics* columns, what was supposed to have been "deregulation" ended up lining the pockets of the utilities, large power consumers, and power producers in the state.

San Diego, California was in the news a lot this past summer. Everyone was hearing about the huge price increases that consumers had to pay. The average electric bill from San Diego Gas & Electric (SDG&E) increased to over US$100 per month during June and July of 2000. At the same time, the media was reporting possibilities of widespread forced outages hitting the state.

The rest of California was not hit by rate increases, but only because under restructuring, Pacific Gas & Electric (PG&E) and Southern California Edison (SCE) had their rates frozen at an artificially high level so that they could be assured profits on their previous unprofitable investments. Many utility customers outside SDG&E's territory did see rate increases, but they were directly offset by an increased "competitive transition charge" (CTC) credit. This shows up as a separate item on the consumer's bill that covers power transmission costs.

But the rate freeze and offsetting CTC will soon be fazed out for the rest of California, as it was with SDG&E. Then the rest of us can also expect a significant rate increase during times of high usage. In fact, the utility watchdog group The Utility Reform Network (TURN) thinks that electricity bills may increase even more than they did last summer in SDG&E territory.

Fighting for the Consumer

TURN is calling for a cap to be put on electricity prices so that this won't happen again. The cap would be temporary, giving the California legislature enough time to come up with long-term solutions to the outrageous prices.

According to TURN Executive Director Nettie Hoge, "Instead of the lower rates we were promised with deregulation, rates are skyrocketing in San Diego. They will do the same in the rest of the state if legislators and regulators don't act responsibly. If rates can be frozen in order to fatten utility company wallets, as they were in order to assure the utilities of CTC collection, they can be frozen to protect consumers, who should not be forced to pay excess profits to greedy generators who are exploiting the current shortages."

There is little doubt that high demand and a finite energy supply is the main cause of the increasing rates. For the last fifteen years, very few homes have been sold without air conditioners, which are installed to make up for lack of energy-efficient design. Poor design, coupled with an increased number of homes, small businesses, and more large manufacturing facilities in California, is responsible for the huge demand we saw this summer. On top of this, there's a lack of new power production facilities being built, and the state is dragging its feet on utility-scale renewables. So you have demand outstripping supply—the perfect formula for rate increases.

Another cause of the high rates has been the ability of power producers and sellers to lock in high bids for power by withholding their supply until demand increases. They are able to keep those bids in effect even after the supply/demand crunch has ended. That is a simplification of the way the power market can work in California, but suffice it to say that the power providers and wholesalers have learned how to work the system to get the most money out of the bidding process, even if it means withholding available power.

Nearly all agree that something must be done, but not all are pleased with the idea of freezing rates. The folks who are producing and wholesaling the power want to continue making a killing on the backs of the consumers. In order to avoid rate freezes, they are spreading the fear that they will sell outside of California rather than putting up with a rate freeze. That, they say, could make power shortages inside California even worse. Sounds like extortion to me.

Coming Soon to a State Near You

California is an early example of utility "deregulation." Other states are looking forward to their own forms, and may find themselves in similar situations of exploding rates. There is still a strong movement in California to repeal the deregulation law to make it more consumer friendly.

So, what does this mean for RE and the environment? One would think that increasing prices would make solar and wind look more attractive. But the fallacy here is that while the payback for these more expensive production methods is shortened by high rates, the motivating factor for building new production facilities is profit, not payback. A profit can be made with wind and maybe solar under the higher rates, but the profit is even better with the building of new fossil-fuel fired turbines.

In California, that seems to be the direction that government influence is taking. The governor has promised to do what he can to fast-track new power plants in order to meet new demand. Turnkey natural gas turbines are available and can be constructed quickly. That means more fossil fuel being burned and less attention being paid to the environment in this "crisis."

So what happened to energy efficiency and conservation? Those items were pretty much thrown out of the mix during deregulation and the years leading up to it. It is no longer a priority in California to try to save electricity, though Governor Davis did recently announce some minor cash incentives for solar energy and energy efficiency.

Guzzoline

Another area where we are getting screwed is with gasoline prices. Collusion and price fixing have become the norm in this industry. Now don't get me wrong—I don't mind paying what a gallon of gasoline is worth, especially if the price reflects the social and environmental costs of driving. What I do object to is the high price of gasoline becoming excess profits for the fuel industry.

Here's what's happening in my neck of the woods. A 10 percent increase (for example) in crude oil cost is becoming a 10 percent increase in retail gasoline costs, and it is being reflected before that more expensive crude oil even gets distilled into gasoline and hits the pumps.

Crude oil is only a portion of the cost of gasoline. There are also the costs of additives, equipment, labor, and transportation that usually do not proportionately follow the cost of crude oil. If crude oil goes up 10 percent, and the other costs remain fixed, why does the price of gasoline have to go up 10 percent as a result?

The oil industry swears up and down that this is completely market driven. I say baloney—the prices are going up due to price fixing among the companies producing and even distributing the fuel. Want proof? Take a look at when pump prices fluctuate. It doesn't happen when the gasoline is delivered, it happens when the station owners get the call from their distributors telling them to increase the price.

In other words, a gas station can take a delivery that completely fills up its tanks at one price, and the fuel can go up again well before the next load comes in. Some state and local governments have begun investigations into how wholesale and at-the-pump pricing is set.

Further proof is that the prices traditionally have increased due to end-user demand during the summer vacation peak-driving periods. That means that fuel costs should have started declining again in September. But here it is the beginning of October (at the time of this writing) and fuel prices actually went up again this month in my area.

Heating Cost Predictions

It isn't enough that summertime electricity and gasoline costs have skyrocketed. Now the industry is predicting fuel shortages during critical winter months. Heating oil is predicted to cost one third to one half more than last year, according to industry and government sources. Hey, they are just prepping you now so that you won't scream too much when you get porked this winter. The oil companies don't like the backlash that can come with sticker shock when you get your first bill and aren't expecting the high prices.

Once again, it is the environment and the consumer pocketbook that suffers. The Clinton/Gore answer to this problem is to increase crude oil supply by making fuel from U.S. emergency stockpiles available to fuel oil companies during the "crisis." Then at some point in time, assumed to be when the demand has decreased, the companies are to purchase their own supplies to give back to the citizen-owned stockpiles.

This plan became a significant issue in the Gore and Bush presidential campaigns. But when did we hear about energy conservation, energy efficiency, and increased availability of renewables? Shoot, you'd think these guys were on the side of oil industry profits rather than what's good for the environment and the people. Wait just a minute—*they are!*

Revolting Development

So what do we want to do about this latest energy crisis? Should we hope and pray that energy prices keep going up so that soon the masses of people will rise in revolt and take back the government from the energy industries? Some would have it this way, and it would be great if it worked. Personally, I think that most Americans are too complacent and soft to take part in a radical revolution.

So that leaves working from within the system. The one thing that we have not successfully tried is massive democratic resistance. We need to continue to try to take political power away from the corporations by supporting candidates and issues who will hopefully clean them up. And I don't mean the lip service that was paid the subject during the 2000 Presidential campaigns.

We need real reform, and the only way we are going to get it is to put public pressure on our elected leaders. Only then will fuel and electricity prices become truly deregulated. Only then will they begin to reflect the societal costs of energy instead of their environmental and social aspects being borne by taxpayers. And only then will renewable energy and energy efficiency get the attention they deserve.

Access

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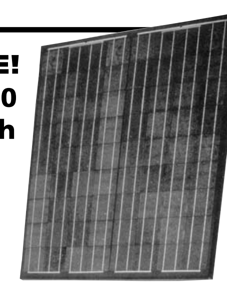

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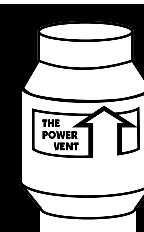

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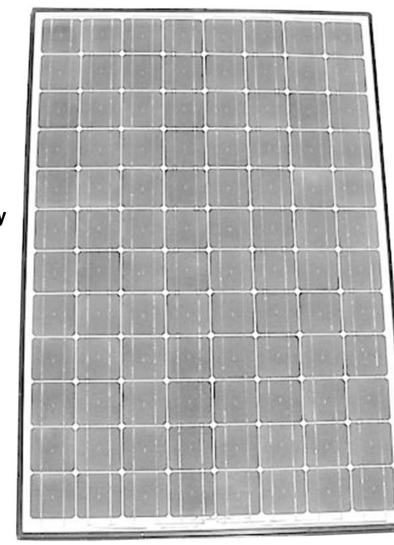

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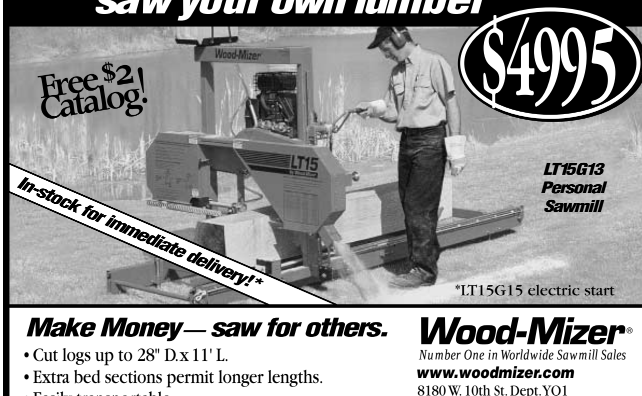

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New IPP Web Site

IPP has a new Web address—www.i2p.org. Along with this new domain, the site has been revamped and updated. The site also has a new feature—IPP will host a national list of dealer-installers.

In addition to dealer location and contact information, there will be a listing of qualifications. IPP dealer-installers belong to a network of “wrenches” established during the last year for the purpose of exchanging technical and product information. This email network is hosted by *Home Power,* and is strictly for installing RE dealers. You can read the archives and get more information by going to www.topica.com/lists/RE-wrenches.

The IPP referral service is an idea initially developed by the wrenches as a service between members. We will offer the service to the public so that potential customers can find a local dealer-installer, and so that self-installers who get into trouble can get help.

All dealer-installers prefer to do “whole systems,” meaning that they are responsible for the design, installation, and sale of the equipment. Having done the whole job, a full system warranty can be offered. But sometimes it doesn’t work out this way. By offering installation and repair service, dealer-installers have the opportunity to establish goodwill, and to support quality system installs. Customers should realize that the whole system approach will yield the best value, and cost less than buying discounted cartons of product and paying for an installation or repair service.

IPP does not endorse the installers listed, but does invite customer feedback, both positive and negative. Listings with multiple complaints will be removed. See our display ad in this issue of *Home Power* (page 127).

Corporate Watch

For some years, this column has kept tabs on the corporate acquisition of independent PV companies. Several years ago, BP-Amoco bought Solarex. More recently, the utility company, Idaho Power, purchased Applied Power and a significant majority of their West Coast competitors (SES and AEE). Idaho Power also bought Ascension Technologies on the East Coast. Last year, Kyocera purchased the distribution company, Golden Genesis (previously Photocomm).

This year, a little known company, Xantrex, made a clean sweep of the major West Coast (of North America) inverter manufacturers. In rapid succession, they purchased Statpower, Trace Engineering and Trace Technologies, Heart Interface, and meter manufacturer Cruising Equipment. In just a few months, Xantrex became the world leader in advanced power electronics.

These acquisitions are interesting because they are strategic. They represent significant signals that renewables and distributed generation are moving towards economic significance. I find the Xantrex story particularly intriguing because the main players seem to be coming from outside the renewable energy industry.

The key to the Xantrex story is understanding what took place about one year prior to the acquisitions. In 1998, the vice president of Ballard Power Systems (of Vancouver BC, a prime developer of fuel cell technology), a Mr. Umedaly, joined the Xantrex board. In March 1999, he was elected board chairman. Xantrex at that time manufactured high quality power electronics, primarily for industrial and commercial customers. Though a very sound company, Xantrex did not have the financial resources to pull off the acquisitions on its own.

I believe that Mr. Umedaly brought considerable resources to Xantrex. Under his leadership, 50 million dollars in capital was secured, primarily from banks and the Ontario Municipal Employees Retirement System. At about the same time, Mr. Umedaly was named CEO. Then Statpower was purchased in October, 1999. In March, 2000, Xantrex secured another 33 million dollars in financing and bought Trace Engineering and Trace Technologies. One week later, Heart Interface

was purchased. To read the complete sequence of press releases, see the Xantrex Web site.

Connecting the Dots
Fuel cells produce direct current. A fuel cell appliance serving households and businesses must contain inverter technology in order to provide 120 VAC. I suspect Ballard will soon be offering a fuel cell alternating current appliance to compete with the GE-Plug Power product now coming to market. Xantrex may well be their supplier of inverter technology.

Utility Disconnect
The ultimate measure of electric competition will be when customers have a choice to take utility service or not. Of course, we are not there yet. But twice now, I have had customers that chose to have the utility disconnected. I also take several calls a week asking about the possibility.

I believe that the utility disconnect market is potentially much bigger than many can imagine. The availability of appliance-sized fuel cells producing both heat and electric power in structures designed for efficiency will forward this possibility.

Marketing Changes at Trace
Some immediate changes in the Xantrex Trace marketing policy seem to be happening. Trace distributors have received a revised policy statement regarding advertising and use of the Trace logo. The new policy essentially prohibits the use of the Trace logo in low-ball ads.

Quoting Salient Sections
"Trace products are technologically complex and therefore require resellers and distributors who have competent, trained service and support personnel to assist purchasers in the installation process and to provide ongoing support in response to user questions relating to product operation and maintenance. Trace therefore regards product sales by organizations that cannot offer this level of product support as potentially misleading."

"It is also Trace's policy that advertising Trace products at cut-rate or bargain prices conflicts with the image that we wish to project for our products, since it places an undue emphasis on price considerations alone at the expense of promoting the service element of our product sales, which we regard as critical in providing long-term satisfaction to the customers of Trace products."

We will see if this policy has any teeth. If it does, Xantrex Trace should be applauded as the first manufacturer (as far as I know) in the RE business to really support the dealer-installer infrastructure.

PVUSA Good News
Two issues ago (*IPP, HP78),* we reported the closure of PVUSA in Davis, California. Originally a utility-owned research facility, it had been operated during the last several years as a test and training facility for distributed rooftop PV systems. The current owner, the California Energy Commission (CEC), lacking operating funds, chose to close the facility last spring.

The good news is that on September 13, 2000, the City of Davis entered into negotiations with the CEC to transfer ownership of the facility to the city. The transaction must take place within six months. Since it is to the advantage of both parties for this transaction to occur, we can hope that a favorable outcome will result. There is one bogeyman in the background, the local utility, PG&E. Unfortunately they could be the deal breaker.

Last issue (*IPP, HP79),* we detailed testimony of the Photovoltaic Distributed Power Coalition presented before the California Public Utility Commission. Briefly, the recommendations included prohibition of utility standby charges levied on PV sites up to one megawatt, and the establishment of fair power transport (wheeling) fees.

Since the State of California has not acted on establishing these or any other policies regarding distributed generation, the Davis-PVUSA deal could be jeopardized by the local utility, PG&E. They may, just as they have already done with other PV projects in California, levy standby charges and prohibit retail wheeling. Optimistically, I want to be wrong, but the pattern of utility behavior is strongly established.

What Is SMUD Doing?
The Sacramento Municipal Utility District's Pioneer 1 and Pioneer 2 programs have been the most successful utility PV programs in the country. As a municipal utility, SMUD is exempt from regulation by the CPUC.

Though IPP has strongly opposed the installation of rooftop PV systems by investor owned utilities, IPP has not been critical of SMUD for two reasons. First, there is nothing legally we can do about their activities. Second, SMUD's behavior reflects the democratic wishes of a majority of the citizens of Sacramento. As long as SMUD's activities remained inside the district boundaries, we have respected the will of the people. However, SMUD's PV and solar programs have harmed independent solar companies in the Sacramento area. Now with deregulation, SMUD is pushing the envelope.

Under deregulation, SMUD is allowed to sell and install rooftop PV systems outside their service territory. On the surface, this might be understood as a good thing

for the public. SMUD prides itself on lowering the cost of PV. They have achieved these price advantages with high volume purchase contracts and by attracting manufacturing plants to the city with subsidized tax rates. Another advantage realized by SMUD is that the program costs are rate based.

None of this is a problem as long as SMUD acts inside its territory. Outside SMUD's territory, low prices based on municipal tax subsidization and customer rate basing look like unfair business practices. These concerns about SMUD are no longer limited to independent dealer-installers in the Sacramento area. Several major module manufacturers have indicated that they understand the problem too.

Los Angeles Water and Power (also a municipal utility) may dwarf SMUD's activities as they replicate SMUD's program. There will be much more heard about these programs. The argument that being green and protecting the environment justifies the adoption of unfair business practices can not prevail. Following that path, both business and the environment will be harmed.

California Legislative Update

California Governor Davis has signed three bills favorable to the solar industry. This is a big deal! AB 918 contains important changes in the way net-metered electricity is valued when excess generation is fed back to the grid. Under the language in the old bill, utilities generally chose to use the average retail value of excess power when figuring the carry forward credit on a monthly bill. Now, that value will be based on the particular retail value prevailing at the time the power is generated.

For instance, if a customer pays on a tiered basis (many customers have a baseline and an over baseline rate) and generates excess power when they are over baseline, they would be credited for the excess power at the over baseline rate.

As another example, some customers have a "time of use" billing. Under this plan, a peak rate is charged during certain times of the day with the intention of discouraging electricity use. In this case, any excess electricity generated during peak rate hours would be credited at the peak rate. If customers managed loads effectively, they would be charged a much lower rate for power consumption taking place at the off-peak rate. The differential would represent a bonus in recognition of the higher value of PV power delivered during peak rate periods. This bonus would be credited to the customer's bill.

Keep in mind that the utility will not be writing any checks. Any credits not used by the end of a one year "true up" period will evaporate. AB 918 represents a significant improvement of the California net metering law. However, net metering is not the best deal for PV. If PV power received its true peak value (at times over one dollar per KWH during this last summer), PV systems would be cost effective today. For more on real time pricing, see *Beyond Net Metering, HP65,* page 76.

California Senate Bill 1345 provides modest support for several distributed generation technologies. The provisions of interest to the PV and solar industry provide a US$750 grant for solar thermal (hot water) systems and battery storage systems used in grid-connected PV systems. By providing assistance for battery storage, the reliability of electric service is enhanced.

With SB 1345, Californians who benefited from the Emerging Renewables buydown can add batteries as an upgrade. Batteries were not eligible as part of the buydown program. SB 1345 should allow a California resident to save about 25 percent on the cost of a solar hot water system or a battery upgrade for their PV system.

A third bill signed by the Governor, Assembly Bill 995, extends the Emerging Renewables program in California for another ten years. By extending this program, a consumer base for customer-owned renewable energy systems can be developed. Additional provisions may allow for low interest loans. Taken collectively, these bills create a real opportunity for sustained growth. Both the PV industry and the energy-using public will benefit directly from these laws.

Access

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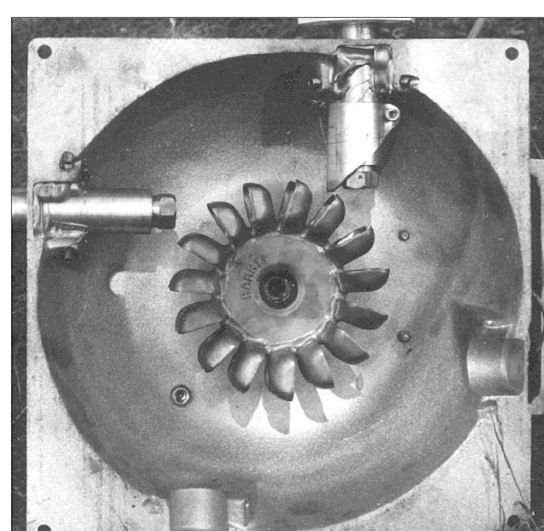

Voltage Drop after *NEC* Requirements

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center, Sandia National Laboratories

After the *National Electrical Code (NEC)* requirements for conductor size (based on ampacity) have been met, the performance question (not a code requirement) of voltage drop should be addressed. In this *Code Corner,* I will show how voltage drops are calculated (no fancy tables), and then I'll cover some typical module wiring installations in the next issue of *Home Power.*

Voltage Drop

First of all, it should be made clear that voltage drop is not a code issue per se. It is a performance issue, not a safety issue in most cases. The code addresses voltage drop only in "Fine Print Notes" that are not part of the code, and are to be used only for added information.

I frequently get calls asking why articles published in *Home Power* and elsewhere on conductor voltage drop do not agree. Each of these articles is based on a set of assumptions that may or may not be consistent from article to article. And a few of the articles have had corrections printed in subsequent issues that may have been missed by the reader. I'll be presenting a method for calculating voltage drop that does not use short-cut tables, just plain old math.

Voltage drop is somewhat critical in PV systems operating at low voltages (12 and 24 volt systems). This is because at night under discharge, batteries have a low terminal voltage, and excessive voltage drop in the circuits causes the loads (including inverters) to operate poorly or not at all. In the PV charging circuits, excessive voltage drops cause wasted power and energy, and require longer battery charging times. In utility-interactive systems, voltage drops and the resultant power losses represent expensive energy that doesn't make it to the load or to the grid.

Current through conductors that have resistance to that current results in a voltage drop developing in a length of the conductor. The relationship is:

$$V = I \times R$$

V (in volts) is the voltage drop in a conductor that has a resistance R (in ohms) and has a current of I amperes (amps). In any circuit, there are two conductors, and there is a voltage drop in each conductor. Since the two conductors are usually equal in length, the distance from source to load (as the conductors are routed) is usually doubled to get a total length that is used for determining the resistance to be used in the calculation.

Conductor resistance decreases as conductor size increases, and resistance increases as conductor temperature increases. Since we are dealing with electrical power circuits, I have selected conductor resistance values from Table 8, Chapter 9 of the 1999 *NEC.*

These DC resistance values, presented below, are for stranded, uncoated copper conductors (no tin or other coatings on the actual copper) at a temperature of 75°C (167°F). This temperature is typical of operating power circuits designed to *NEC* requirements and will not, of course, match similar conductor resistance values at

Resistance of Copper Wire

Size	*Metric Size (mm^2)*	*Ohms / 1,000 ft.*
14*	2.08	3.1400
12*	3.31	1.9800
10*	5.26	1.2400
8*	8.37	0.7780
6*	13.29	0.4910
4*	21.15	0.3080
3*	26.67	0.2450
2*	33.62	0.1940
1*	42.41	0.1540
1/0*	53.48	0.1220
2/0*	67.43	0.0967
3/0*	85.01	0.0766
4/0*	107.22	0.0608
250**	167.70	0.0515
300**	201.30	0.0429

* AWG
** kcmils

other temperatures. AC resistance and impedance values may be significantly different, and are beyond the scope of this article. DC values may be used only as a very rough estimate for AC circuits.

To get the resistance R for the voltage drop calculation, double the one-way length of the circuit from source to load. If the circuit (source to load) length of the conductors is 40 feet (for example), the total resistance would be based on a length of 80 feet (2 x 40). If 10 AWG (5 mm^2) conductors were being used with a resistance of 1.24 ohms per 1,000 feet, then the resistance R for the voltage drop calculation would be:

R = 1.24 x 80 ÷ 1,000 = 0.0992 ohms

Now we have to consider what current to use in the equation. As current increases, the voltage drop also increases. In utility-interactive PV source circuits, I tend to use the rated peak-power current of the module (marked on the back of the module) or group of modules connected in parallel.

In a battery-charging system, the peak-power current might also be used, but some consideration should be given to using the short-circuit current from the modules or the PV array. This higher current might be used, since at low battery states of charge, the module currents tend toward this value due to the low battery voltages.

For example, a PV module might have a short-circuit current of 3.5 amps and a peak-power operating current of 3.0 amps. For a system with ten modules or strings of modules connected in parallel, I might use 35 amps as the current in a battery charging system, and 30 amps as the current in a utility-interactive PV system.

In DC load circuits, I use the maximum steady-state currents for the DC loads or the inverter. If there are high motor starting surges on the inverter, they might cause the inverter to shut down as the surge causes the voltage at the inverter input terminals to drop to the low voltage disconnect point. I would at least calculate the voltage drop at these high surge currents.

In a battery-to-inverter circuit, the maximum steady-state DC current into the inverter might be 100 amps (for example) and I would use that current in the calculation. However, if there were well pumps or sewerage lift pumps operating at night that had peak currents of 300 amps, I would see what effect this higher current, and the resulting voltage drop, would have on the inverter operation.

With the resistance established and the current estimated, the voltage drop can be calculated.

For example, an inverter is located 20 feet (circuit length) from the batteries and is connected to a resistive load (no surges) that causes the inverter to draw 100 amps on a 24 volt system. Yes, this is a heavy AC load at about 2,200 watts. The low voltage disconnect is set at 22 volts. 4/0 AWG (107 mm^2) conductors are being considered.

The resistance R is calculated as:

R = 0.0608 x 40 ÷ 1,000 = 0.00243 ohms

The voltage drop is 0.00243 x 100 = 0.243 volts.

The operating voltage of the inverter is 24 - 0.243 = 23.76 volts when the batteries are at the nominal system voltage of 24 volts.

Now let's see what happens when there is a well pump on the inverter output that causes the inverter to require a surge current of 300 amps from the batteries. The conductor resistance will cause the voltage drop to increase to 0.729 volts. This drop alone would cause the inverter terminal voltage to drop to 23.27 volts in a good battery bank.

However, the internal resistance of the batteries and other resistances in the circuit will also cause a voltage drop. The total voltage drop may cause the low voltage disconnect point of 22 volts to be reached, shutting down the inverter.

Finer Points

Ah yes, batteries have an internal resistance that varies all over the place depending on the type of battery and the state of charge. These are very hard numbers to pin down and verify. For golf cart batteries and L-16 style batteries, I use 0.00075 ohms per 6 volt battery. I just add the number of 6 volt batteries in series and use that number times 0.00075 and add this to the conductor resistance. That comes out to 0.0015 for a 12 volt system, 0.003 for a 24 volt system, and 0.006 ohms for a 48 volt system. Remember that these are just ballpark numbers—your mileage will vary.

Contacts in connectors and switchgear also have resistances. I use 0.0002 ohms for each good battery terminal, power block terminal, split-bolt, or twist-on wire connection. I use a resistance of 0.002 ohms for each circuit breaker pole and a resistance of 0.006 for each fused disconnect switch pole (this accounts for the resistance of two terminals, the switch blade, the moving contact, the fuse element, and the two fuse blades).

Again, these are very rough estimates for well-made connections and devices, and the actual numbers will vary widely. High-current devices will usually have lower

Example Circuit Resistances

Type of Resistance	*Ohms**
Battery internal resistance	0.0030
Battery contacts (8)	0.0016
Inverter contacts (2)	0.0004
Circuit breaker	0.0020
Conductors	0.0024
Total	0.0094

* Very rough estimates.

resistances than low-current devices. The resistances for each circuit are composed of the conductor resistance plus the battery internal resistances, plus all contact and switchgear resistances.

In the preceding inverter example, let us assume that the 4/0 AWG (107 mm^2) cables are routed through a single 250 amp circuit breaker. The circuit resistances are now as shown in the table above.

At 100 amps, the voltage drop is 0.94 volts. During a 300 amp surge, the voltage drop is 2.82 volts, which might just cause problems. Some of this voltage drop, but not all of it, can be reduced by using larger conductors. This is one of the reasons that getting good, tight, quality connections is necessary in a PV system. Every milliohm counts.

Percentage voltage drop may be expressed as the voltage drop divided by the nominal system voltage and then multiplied by 100. In this example, the voltage drop is $0.94 \div 24 \times 100 = 3.9$ percent for the 100 amp load, and three times that for the 300 amp surge.

I try to keep the voltage drop below 2 percent for 12 and 24 volt systems and below 3 percent for 48 volt systems. Higher voltage systems can sometimes carry higher voltage drops. But the operating points and losses of power should be compared with the costs of increasing the conductor sizes to reduce those losses.

In many cases, the resistance of switchgear, poor connections, and aging batteries may cause far more voltage drop than the conductors alone do. Increasing conductors above the code ampacity requirements won't help much, but may be necessary.

In many cases, long distances between the PV array and the batteries might indicate that the conductors may require oversizing to lower the voltage drop. If the circuit conductors are increased above minimum ampacity requirements, the equipment-grounding conductor for these circuits may also have to be increased. See previous *Code Corners* and *NEC* Section 250-122 for details.

Summary

After the code-required ampacity calculations are made to determine the size of the conductors, additional calculations should be made for the voltage drops in the system. If these voltage drops are excessive, increasing the conductor size may help to reduce them.

If you have questions about the *NEC* or the implementation of PV systems following the requirements of the *NEC,* feel free to call, fax, email, or write me. Sandia National Laboratories sponsors my activities in this area as a support function to the PV Industry. This work was supported by the United States Department of Energy under Contract DE-FC04-00AL66794. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

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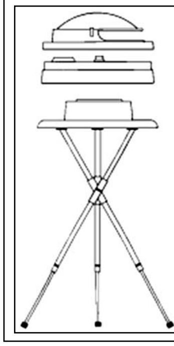

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When Karen and I were living with kerosene lamps, we went to our local public library to find out if there was a better way to light up our nights. We found nothing about small scale renewable energy.

One of the first things we did when we started publishing this magazine twelve years ago was to give a subscription to our local public library.

You may want to do the same for your local public library. We'll split the cost (50/50) of the sub with you if you do. You pay $11.25 and Home Power will pay the rest. If your public library is outside of the USA, then we'll split the sub to your location so call for rates.

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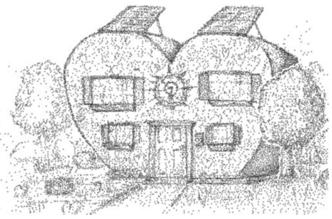

Kathleen Jarschke-Schultze

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After retiring from *Home Power* over a year ago, I had visions of pursuing my own interests. I wanted to devote more time to my bees. I had been saving and reading material on soapmaking, both the lye/fat kind and the glycerine kind. And I fully expected to be writing more.

Garlic Queen

Before *Home Power* and Hornbrook, I grew and sold garlic. I raised only one kind of garlic. It was a soft-neck variety that could be braided easily. I grew many kinds of everlasting flowers that could be dried and braided into the garlic braids and wreaths. I didn't make a lot of money at this. But it was satisfying work, and it could be done at Starveout, the old mining claim where we lived at the time.

When we moved here, I began growing garlic because it seemed strange and wasteful not to. I acquired a wonderful array of garlic varieties from Filaree Farm in Okanogan, Washington. I started growing the local garlic started here by the early homesteaders on Agate Flat. By the time we really got settled in at our place on Camp Creek, I was growing twenty-five types of garlic.

Two years ago, I lost all of the year's garlic crop. At a critical time of harvesting the current crop and planting the next year's crop, my mother became tragically ill and passed away. My time spent with her then was priceless and I am without regrets. So last year I began acquiring varieties again. I am building up seed stock for a mid-sized garlic production. I am growing hard-neck and soft-neck varieties now. By next year, I hope to have some to sell.

The Bee Codger

Last year I started keeping bees. I got two hives and lost one. This spring I got four more hives. I had a disappointing harvest, although the bees seem to be doing okay getting themselves stocked for winter.

This spring I set up a hive for my 83 year old Dad down in Paradise, California. We started late for his area. I had a little trouble finding someone to sell me a package of bees to get him started. So his hive was set in place the last week of April.

In the last week of July, I took my extractor down and we got four gallons of honey from Dad's supers. My brother and his girls helped Dad extract another four gallons at the end of August. My sister got a few more gallons in the final extracting in September before starting the fall medicating of the bees. We figure Dad got about 100 pounds of honey from his one hive. Now we call him the Bee Codger.

Of course he just spoils his bees. He hung a shirt he had recently worn on a pole by the entrance of the hive. Pretty soon he was able to work the hive without a veil or gloves. He would go out four or five times a day to check on his bees.

He made them a self-maintaining watering pan with rocks in it so the bees wouldn't drown. He covered the hive stand legs with a coating of used motor oil to keep the ants from bothering the bees. Then he carefully made covers for the oily legs with cereal box cardboard so the bees wouldn't get caught. When the summer sun heated the hive, Dad made a little shade roof so the bees wouldn't have to work too hard ventilating their hive.

I don't begrudge Dad his amazing success with his hive. I am a little jealous though. And he does give me something to strive for.

***HP,* Then EC**

Once again I am doing office work from my home. Now I work for Electron Connection. My status as a non-techie is in jeopardy. After living with renewable energy for sixteen years, I am now learning the basics of RE system components and their usage.

The Bee Codger.

It is amazing how little I knew. With Bob-O knowing everything, I just didn't have to. I guess my brain is on a need-to-know basis. Well, now I need to know. I like working with Bob-O. I've always considered our union a partnership, and this is just one more facet of our marriage.

I fill, place, and ship orders, send out bills, and track shipments. I function as a live person answering the phone when Bob-O is gone on an installation. My time at *Home Power* has helped, since most people in the industry know me already, even if I didn't know them.

Since his office is in what we laughingly call "the dining room," I can get other things done around the house while I'm working. I got a snap-on belt and pouch so I can even work in the garden and still answer the cordless phone. I have to catch myself occasionally since I have a tendency to answer "Home Power" instead of "Electron Connection."

Renewable Vows

We went to a wedding recently. Some dear friends of ours got married. As part of the ceremony, Bob-O and I renewed our vows after fifteen years. The reason most of the people at the wedding knew each other and had become friends was their mutual RE lifestyles. The conversations at the reception included a lot of talk of systems, their components, and the future course of the industry.

The wedding was held at Lake Tahoe's North Shore. Bob-O was appalled at the resort's lack of knowledge or usage of compact fluorescent lighting. For all the lights that are left on 24/7, the power consumption could be cut considerably.

Nevada seems to be trying pretty hard to be aware of renewables. We picked up a newspaper in Reno and it had a twelve page insert called *The Nevada Renewable Energy Guide 2000.* It was filled with articles on how Nevada could take advantage of deregulation of the power industry.

With articles explaining wind power, solar power, and geothermal power for the layman, and ads for local dealer/installers and component manufacturers, this insert was great. More states should be following Nevada's lead in informing their people about renewable opportunities.

Nevada's governor, Bob Miller, has proclaimed that their state is one of the few in the nation with the potential to become totally energy independent through investment in energy efficiency and the development of renewable, indigenous resources such as solar, geothermal, wind, and biomass.

Nevada is striving for 10,000 solar roofs as part of President Clinton's million solar roofs challenge. If you go to the Million Solar Roofs Web site, you can download a booklet called *The Borrower's Guide to financing Solar Energy Systems.*

Access

Author: Kathleen Jarschke-Schultze is starting her soapmaking adventure at her home in northernmost California, c/o *Home Power,* PO Box 520, Ashland, OR 97520 • kathleen.jarschke-schultze@homepower.com

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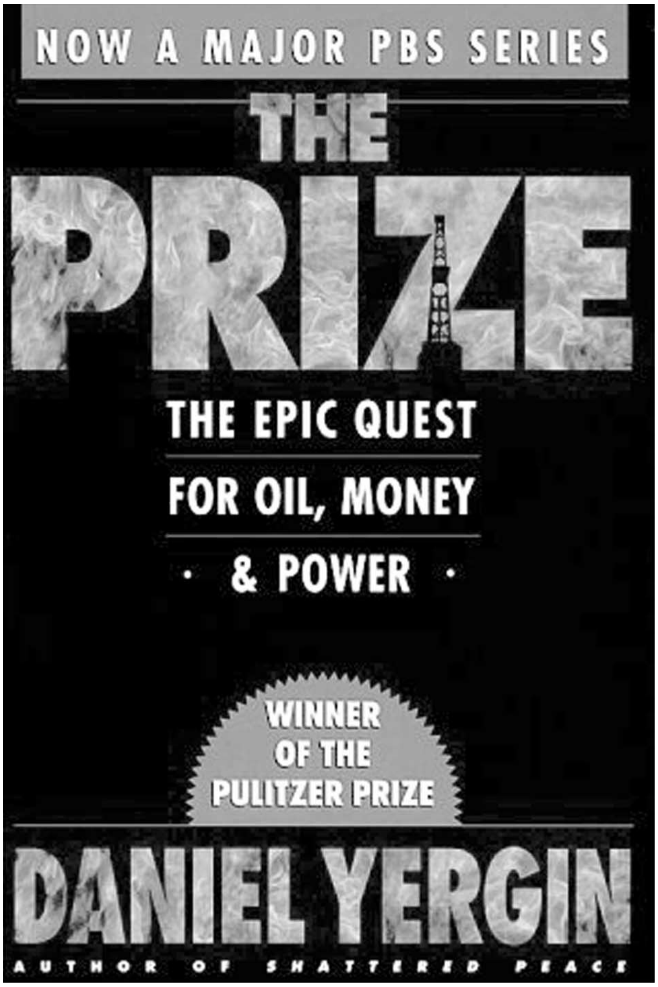

By Daniel Yergin
Reviewed by Chris Greacen

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Many of us are interested in effective ways to spread renewables in an attempt to avoid the environmental impacts of fossil fuels. Or we turn to renewables for reliable power independent of giant energy corporations like oil companies or utilities. Either way, as energy activists and clean-energy pioneers, we should know the relevant history.

The Prize, by Daniel Yergin, is a history of oil. This 928 page book begins with the early development of the oil industry for kerosene as lighting fuel in the 1860s. It then follows the enormous growth of the oil industry until the events leading up to the US/Iraq war. Through anecdotes and analysis, *The Prize* traces oil's powerful influence in the world economy through two world wars, the rise of OPEC, and subsequent price shocks.

The book follows three broad themes. The first is the role of oil in the rise and development of capitalism and modern corporations. Oil is the world's biggest business. Of the top twenty companies in the Fortune 500, seven are oil companies. How did they get this big? What do oil companies want? What do they do to get it?

The second theme is the crucial role of oil in national strategies, global politics, and power. Oil (or the lack of it) had a lot to do with Japan's attack on Pearl Harbor. Yergin makes a compelling argument that Japan and Germany lost World War II in large part because their fuel tanks were empty.

Oil subsequently played a large role in the Cold War years. Developing countries battled each other and fought international oil corporations for control of oil, while the USA and USSR supplied weapons and support as they saw fit. Two of many indications that oil remains a central strategic resource in a post-Cold War world are "Operation Desert Storm" and now oil man George W. Bush as Republican presidential candidate.

The third theme is the emergence of "Hydrocarbon Man." We have become a species dependent on oil for nearly everything: transport, heat for our houses and industrial processes, energy and fertilizers for agriculture, and the plastics and chemicals that surround us. Yergin details how our consumption and reliance on oil have grown, and how it has changed the way we live, work, play, eat, and breed. But he falls short in exploring the implications these changes hold for the environment and for society.

This brings me to my main criticism of the book. *The Prize* ignores the stories of the communities (human and other critters) that were poisoned, polluted, or displaced by the impacts of oil production and processing. But that's another 900+ page story…. *The Prize* provides important background for understanding and telling these and other tales.

Access

The Prize: The Epic Quest for Oil, Money and Power, by Daniel Yergin. ISBN 0-671-79932-0. 928 pages, 16 pages of photos. US$18 from Touchstone Books, Simon & Schuster, 100 Front St., Riverside, NJ 08075
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El Paso, TX. El Paso Solar Energy Association: meetings normally held 1st Thurs. of each month. EPSEA, PO Box 26384, El Paso, TX 79926 915-772-solr • epsea@txses.org www.epsea.org

Houston, TX. Houston Renewable Energy Group: meetings last Sunday of odd-numbered months at TSU Engineering Building, 2 PM. HREG, PO Box 580469, Houston, TX 77258 jferrill@ev1.net www.txses.org/hreg/HREGhome.htm

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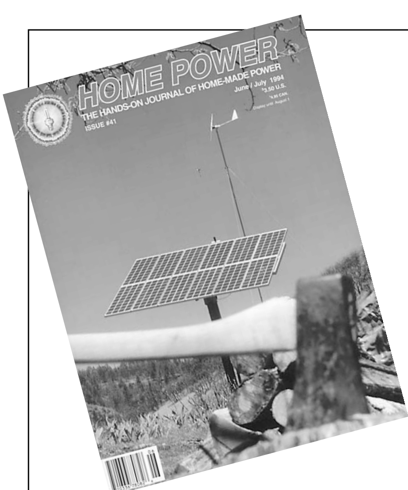

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VISA

Errata

In HP79, *I stated that a PV module displaces one metric ton of CO_2 annually. Would that it were true. Actually, a* one kilowatt *PV array displaces one metric ton of CO_2 annually. Richard Perez*

Skimpy CDs?

Hi Folks, I see on my mailing label that it's time to renew, so enclosed is the renewal form and a check. I've been with you guys since *HP3* and I always look forward to the arrival of the next issue.

That said, I do have one concern that I feel I must bring up. It's about *Home Power* CDs and the dwindling number of issues on each one. Even though I have all the paper issues of *Home Power,* I've been very enthusiastic about the CD-ROM versions. This is especially true since I work on a ship and can bring them along for reference while I'm at work. The first few CDs were really killer deals, but I have noticed that each subsequent one has had fewer issues on it than the one before. *Solar5,* with only six issues on it, makes it more expensive than a subscription to the paper version. What's up? It can't possibly cost more to produce than the magazine, does it?

I know that you throw in a lot of other stuff. Since I haven't seen *Solar5,* I won't make any judgement on the value of guerrilla solar video, audio lectures, etc., but I will say that as a customer, my main reason for buying the CD is for the electronic version of *Home Power.* I may still buy *Solar5* since I would like a complete set, but I'll have to give it some thought. I hope you will reconsider the direction you want future CDs to be going before *Solar6* comes out.

I don't mean to be too hard on you guys. I really do appreciate all the hard work you've put into making *Home Power* a top notch magazine. I know the type of world you are advocating will be a much better one than the alternative path would be. Thanks for your efforts, Mark Keen, Appleton, Washington
markbert@gorge.net

Hello Mark, We had a tremendous backlog of issues to put on the early CDs. Also, those early issues contained no digital photography, so their byte count was small. Since we are issuing the CDs yearly, we now have only six issues to place on a CD. But each CD is chock full, with no wasted space. We're filling the later CDs with working RE software, databases, audio lectures, and even guerrilla solar video on Solar5. Solar6 *will be a two-CD set, with the second CD devoted entirely to educational RE videos. In my opinion, the working electronic indices on the CDs makes them far superior to the paper editions, and more than worth the price of admission. Richard Perez*

Hi Mark, In producing the Solar *CDs, we try to deliver as much useful information as possible. Going into this, we knew the day would come when the CD would contain the issues from only the past year. So we started looking into delivering information we can't bring you in print, such as audio, video, database, and program files. Based on the responses we've had to date, this has been very popular. While I don't have more issues to put on the CD, we'll do our best to keep packing them with useful information. Don Kulha*

One More Time & *HP* 12 V Schematic Errata

Dear Richard, I have been a subscriber for about three years. I am renewing one more time. But I have come to the point that the expense of renewable energy and the grid do not add up. What I mean is, buying PVs and the equipment is not cost efficient. I have studied the idea of the Trace plug in the wall inverter and a couple of solar panels. What little the panels would put out to supplement the grid usage did not come out as a savings at all. I realize this could be debated, but I look at my pocketbook.

Also from what I have read in past issues, I find it amazing that people want to be independent, but rely on government to help supplement the purchase of PV power for "The Million Solar Homes." I went to the Florida Solar Web site and found that they have way too many strings attached to receive federal grants. So are we really independent? Looks to me like the companies themselves and the technology that exists could make a real difference in how much PV power costs and be totally independent from the government's help.

Lastly, I was disappointed in the *Home Power's 12 Volt System* article schematic *(HP78,* page 44). The one in particular was the PV Sub-Array #2. The other two arrays showed how the PVs were wired. I am not an electronics genius, but I can follow a schematic. This one picture of how to wire different sizes and watts together is what interested me the most, but alas, no wiring. So, where can I get a wiring diagram of #2 array?

The most I will do and can afford will be small PV projects that make outside lights work at night or charge a battery. But I am not holding out that prices will fall dramatically to make the most of renewable energy. Sincerely, Glenn Polsey, New Orleans, Louisiana

Hello Glenn. Space didn't permit us to show all the wiring on Sub-Array #2 of our 12 volt system. All the modules are wired in parallel—plus to plus and minus to minus. Richard Perez

Hi Glenn, After reading your letter where you mention PV Sub-Array #2, I went to go look at the schematic. I opened up the issue and my eye zoomed in on the wiring for PV Sub-Array #1. We didn't catch this mistake before it went to print—the wiring is wrong on the eight Kyocera J-51s.

Sub-Array #2 may look complicated, but actually it's pretty simple. Check out PV Sub-Array #3 in the schematic. All the positive leads are hooked up together, and all the negative leads are together. All three arrays, including the Democracy Rack (Sub-Array #2), should be wired just like Sub-Array #3—in parallel.

The reason these panels are all wired in parallel is because they are all 12 volt panels in a 12 volt system—each panel is already at the nominal voltage of the system. When we hook up these 12 volt panels together in arrays, we don't want to increase the voltage. Remember the basics—wiring in parallel increases the current, while wiring in series increases the voltage.

When hooking up an array with modules wired in series (in a 24 volt system with 12 volt panels, for example), current does become a factor. With series wiring, Kirchhoff's law comes into play. Kirchhoff's law states that the amperage in a series circuit is the same throughout the entire circuit. Because the PV panel is a constant current device, the panel with the lowest amperage rating will determine the amperage of the whole series string. Basically, the weakest link in the chain determines the strength of the chain. So in the case of an array hooked up in series, you want all your panels to be the same (same make, model, rated wattage, etc.), so you won't be limited by the lowest current.

Off the paper and into the multi-dimensional world of Funky Mountain Institute, all three 12 volt sub-arrays are really wired in parallel, as shown in Sub-Array #3 on the schematic. Joy Anderson.

Hello Glenn. Sorry to hear of your disappointments. Yes, PV is more expensive than the grid in most cases. And yes, the user subsidies for

PV power usually come with some kind of strings attached. But in most states those strings are not detrimental to the use of the system. They usually involve the criteria for how a system is installed (according to the NEC), *and how it is metered. Most net billing states give your excess power back to the utility for free.*

Last I looked, Florida did not have a net metering law, which means that your utility is only required to give you "avoided cost" for your power, and not offset your utility bill. You cannot just run your meter backwards, unless you can get the utility to agree to that on a case-by-case basis. Many states without net metering laws also require inconvenient and unreasonable connection requirements, including double meters, extra meter reading fees, and sometimes even a multi-million dollar insurance policy to protect them.

Maybe it is time for you and others in your situation to get active in your state to pass a decent net metering law, which would allow you to run your meter backwards to offset your home's usage.

The subsidies question is a whole can of worms. Many don't believe the government should be supplying any kind of financial incentive to develop or install PV. We all wish that there was an even playing field for the different kinds of energy. But, the sad fact is that the powerful oil, coal, and nuclear lobbies have gained untold billions for their particular types of energy.

The only recourse is for the public, which likes RE, to try to get their own subsidies to try to offset the deadly utility-oriented technologies. Our lobbies are not nearly as powerful, so what we get in subsidy is a drop in the bucket compared to the polluting technologies. We need to take advantage of everything we can get, only to increase the height of our end of the playing field as much as possible. But, once a PV owner has taken advantage of those subsidies, the system is theirs, and they do certainly enjoy the independence of that ownership. Michael Welch

Hi Glenn, I'm one of the people Michael refers to above. I am not at all in favor of government subsidies for renewables. I think it's a very ugly system that we should not get wrapped up in. It's based on taking money from people, siphoning a large portion of it off for bureaucracy, and then giving the grants or subsidies to the folks with the most power and influence. It's a dishonest and inefficient way to get what we want. You only need to look at how entrenched and powerful the utilities are to see the corrupting influence of political funding. Why we would want to put renewables into this ugly system is beyond me. We saw what it did to the quality of products (particularly wind generators and solar hot water panels) in the past.

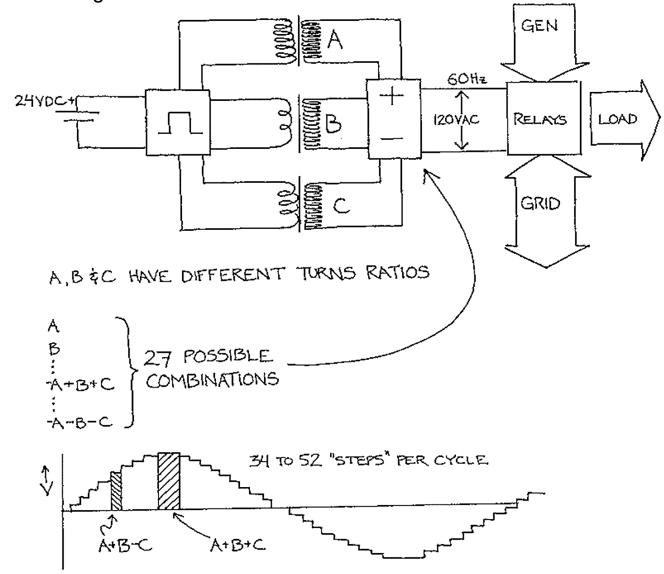
Instead, I believe that we should continue to speak out strongly against all subsidies for dirty energy. If renewables were in a free market, with non-renewable energy generators held responsible for the full cost and effect of their systems, renewables would come out looking great—both for the environment and for our pocketbooks.

And perhaps the most powerful thing we can do is to make changes in our own energy use to lighten our load, and work towards using renewable sources in our own lives. Ian Woofenden

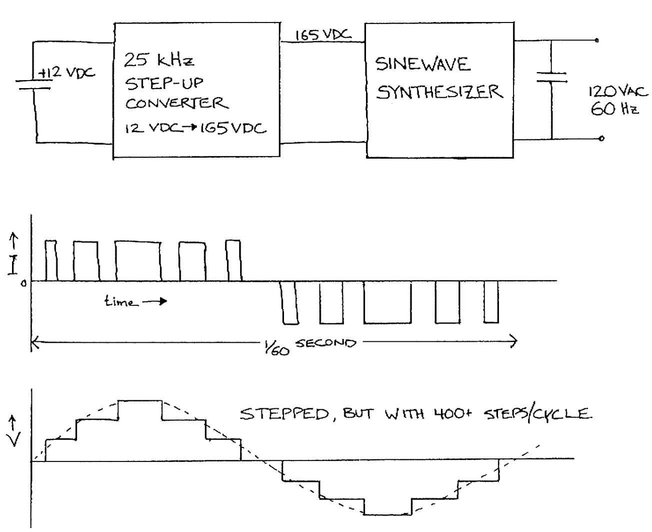
Sine Wave Inverters

Dear Richard, I've enjoyed the recent discussion about the inner workings of the Trace SW series inverters. Attached is a drawing of a simplified Trace SW series schematic I made for a presentation on inverters that I gave at U.C. Berkeley last year. I came to the same conclusions as Alastair Couper *(Letters, HP78).* The Trace SW uses three transformers with different turns ratios. The transformers are driven by 24 VDC pulses from the primary side. Their secondaries are added or "subtracted" (added with reverse polarities) in series to create 27 different voltage combinations that are sequenced to make the sine wave. As the battery voltage changes, a microchip in the inverter has to choose different sequences in order to keep the sine wave voltage in the right range. The pulses used to make the sine wave can have different durations, thus there are 34 to 52 steps per 60 Hz cycle.

Alastair notes that for making a sine wave inverter like this, "There are, of course, a number of other methods. A transformerless inverter could produce a digitized sine wave in a similar fashion. An array of ten independent, high frequency, DC to DC up-converters would step up the battery voltage in a series of increasing voltages from close to zero on up to the 170 volt peak of the sine wave." I think Alastair is right. But such a design wouldn't allow the inverter to have the cool bi-directional power flow capability of the Trace SW, which is made possible by the use of transformers. When the Trace SW wants to pump power onto the grid, it simply generates a waveform with slightly higher voltages than the grid. When it is in battery-charging mode (pulling electricity from the grid or a generator), it generates a waveform with lower voltages than the AC charging source. Hats off to the engineers at Trace!



I disagree with Alastair on how the Statpower (as well as Exeltech and other transformerless sine wave inverters) probably works. Instead of many DC to DC converters linked up in series, I think they just use one DC to DC converter to step up the voltage to 165 VDC or so. Then it uses a high voltage FET pulse width modulator or "sine wave synthesizer" to break up the 165 VDC into lots of current pulses of varying durations (see illustration below). There are hundreds of these current pulses per cycle, half with positive and half with negative polarities. With a load or a little capacitance across the output, the result is a pretty nice sine wave. Chris Greacen cgreacen@socrates.berkeley.edu



Gas-Fired Utility Backup
Dear Mr. Perez, Sometime recently I saw some surprisingly positive statements made about Wisconsin Electric Power Co. (WEPCO) in *Home Power.* I think it was related to their "alternative energy program." Frankly, I shudder to think what they will be able to do with any form of energy. They ran up a record number of safety violations at the Point Beach nuclear plant.

But the main point of my letter concerns the enclosed materials [ed. note: John sent us some info and brochures on Wisconsin Gas grid backup generators]. WEPCO is so unreliable at delivering electricity that the local gas company, WICOR (which, unfortunately, owns Shurflo, maker of DC water pumps) is now offering gas-fired power plants for the homeowner in the Milwaukee area. (Ironically, there has been talk about the two companies merging. Hmm.) I'll bet they don't put WICOR through the same hurdles that they put us through when we want to install an "individual power plant." Yours, John R. Surber surber@csd.uwm.edu

Insurance Fears
Richard, I have been getting *HP* at the newsstand for the last three years, but just now got a subscription. I have my ham radio station solar powered now. My wife and I are expanding and building a home with an RE system, with about 1 KW solar and 1.5 KW wind in the plan. Here's the big question: Who insures RE homes or their systems? I have my home now and the house we are building insured with our local American Family rep and have had great service forever (no claims yet) from him. However I am unsure that I want to bring the issue of RE generation up to him for fear he will cancel my plans or my policy.

Can I insure the house for "normal stuff" with them and insure the power system with a second party? I would hate to have a major claim denied because of a loophole. Should I consider it all personal property, or get a special rider on it? I am sure I am not the first lost sheep that has asked this question. I just don't want to spend big bucks on an off-grid system only to be at a total loss if there's a fire or tornado. This is very important to me because I will do my own install in a rural area that requires no permits or inspections.

Any advice you can give would put my mind at ease and our family one step closer to being off-grid. Thank you so much for your time! Jeremy Engbrock N0NZG & Sandra Engbrock KB0YXI N0NZG@aol.com

Hello Jeremy and Sandra, Most folks have the RE systems as part of their standard homeowner's insurance. I'll print your letter and we'll get some feedback from our readers. I don't think that having an RE system on the policy is any big deal. I do know that the insurance people like power sheds. Having the battery outside of the house is a plus for them. Richard Perez

Jeremy and Sandra, The bottom line in insurance policies is the fine print. Review your policy carefully, and if it appears to exclude anything that might have to do with your RE system, you're out of luck. If you find some things you are not sure of, run them by a local attorney. They are trained in deciphering the legalese in your policy. If you are not sure, but feel that your policy might exclude an RE system, ask your insurance agent to get a written interpretation from the insurance company that will allow your RE system. If that fails, find a new insurer. Whatever you do, it is unwise to just take their word for it without something in writing. No matter what he tells you, your agent's spoken word is superceded by the fine print on the policy. Michael Welch

Flight Fright; Renewable Fright
Dear Richard, I read all the gory details of your flight to MREF this year. Yes, sometimes the airways are very muddy. I wish it weren't so. Some of us spend our entire week there, so we always pack an umbrella.

Your route was Medford to Portland, to Denver, to Madison, I believe, before rerouting through Chicago. That's three airplanes, two connections, for a weekend trip across the country during thunderstorm season, right after school let out. When your first two hour delay in Portland forced a missed connection in Denver, you said the dinner was impossible to make. It sounds like your military precision plan didn't leave room for a single contingency.

Most of the frequent travelers I talk to have plenty of war stories to tell. But if they are going to an important meeting, they never make plans to catch the last connection. You may have tightened the screws on that thin case a bit tight, so I'm not surprised that when somebody dropped it, it developed more than a hairline crack. I'm very sorry you missed the dinner this year—I know Friday night at the fair is a great time. Me? I missed the entire fair—I had to work. You didn't mention how Ian, Don, and Michael fared, except that they had to cover for you at dinner. I assume they had better luck then. And you are correct in not beating up on the service agents. Their job is the worst in the business, and like you, they are along for the ride. They can be your best friend on a rainy day like yours. Your experience going to New Orleans rerouting through Cincinatti (Delta?) has served you well. Now let me tell you my war story.

We have a small place with good wind and sun and existing utilities, but decided that renewables made sense. We started with an AIR 303 wind plant, Solarex VLX-53 panel, some batteries and tools. For two years we made small inroads into energy production. After four blown wind plant regulators, one tower fall that put my brother in the hospital briefly, a few shorts and dead batteries, and other surprises, we moved on. Now we have a professionally installed Rohn tower with a Whisper H-40 wind plant on top, L-16 batteries and an SW4024 inverter, plus some extras in the garage.

We were fortunate to receive a small state grant to help with the expenses. This puts your name up for grabs by any would-be sales rep that wants to bother reading the books. There are two installers in our area, both experienced, reputable people. I later learned that legal actions occurred between these two installers over access to my and others' names on that state list. Both installers have known each other for years, so I can only imagine what was happening behind the scenes.

Our first inverter came damaged in the box, and had to be sent back, costing us several weeks delay. Once the second was wired in, everything worked, and we passed the wiring inspection two days later. About nine days later, the inverter died while I was away one night. We sent it back for warranty work, and were advised that it would cost US$575. We were told it had been struck by lightning. This was very hard to swallow since we got just a few days use from it, and there is no mention of lightning damage in the Trace warranty—you can look yourself. After long discussions with our installer and Trace, Steve Higgins of Trace Warranty stepped up and covered the cost, partly because our first unit came damaged, and partly because we have a very well built system. I have over US$10,000 in parts in my garage, Richard, and that's before the solar panels. We didn't cut any corners.

Now I've learned that my existing lines from the garage to the house panel are undersized for the inverter to carry all the loads, so the project will run more money over budget and further behind schedule. But I'll tell you what—we're going to go through with it. It's important to us, and to the 5th grade science class kids who will visit it regularly.

I learned plenty in 1998 at MREF, the last year we were able to attend. We attended several workshops, including yours on inverters and batteries. Your stories about batteries blowing up, towers falling, and other unexpected tragedies were inspiring to us, mainly because in the face of the unknown, you persisted. That was during a time when the renewable business was busy getting black eyes from fly-by-night installers selling anything to the homeowner for a tax writeoff.

Without any good help or information in the area, you stood up and made it work.

Well the airlines are clearly getting black eyes today, and going through a time of unprecedented change. In the last decade, multiple bankruptcies, mergers, buyouts, employee ownership, foreign ownership and partnership schemes have laid to waste all that the business knew about itself. Add to it record demand and growth, job training and equipment replacements, and the particularly bad weather we have had the last two summers, and you have quite a mess.

The difference is that there is no shortage of information about it. Every day there are headlines about what airline stranded the most people on which runway, while congress mulls over the latest amendment to the passenger bills of rights that still have not been passed. Even the individual airlines have Web sites that can tell you how a particular flight has fared the last month or so in on-time arrivals. It isn't hard to plan ahead for this type of problem—practically everyone else has been there.

What surprised me, Richard, is that you gave up on air travel so quickly. I've done a little flying myself, and I just want to say that if you find yourself in a bind one day trying to decide if you want to try flying one last time, call me—I'd be happy to offer my advice. Sincerely, Rudy Ruterbusch, First Officer, United Airlines, Elberta, Michigan

Thanks, Rudy. We're still flying and have only been slightly hosed on our last two journeys. I think that part of our problem with air travel is that we are country folks who are used to relying on ourselves. Once we get sealed into that aluminium sausage, we are totally out of control—we have to rely on the airlines to do their job, and become miffed when they don't. I understand the innate vagaries of air travel. You are correct, we should allow extra time for delays and not schedule things too closely. We're doing that now and on future flights. I've probably flown several hundred thousand miles in my life, and I'm still alive. So I'd have to say that, overall, the airlines haven't really let me down too hard. Having said that, I'd still rather drive if at all possible.

Your RE experiences are shared by others. The Air 303s had chronic regulator problems as you discovered. The new 403s have solved this problem, and several other problems as well. It must have been someone else who told you of the tower problems because I've never had one come down. I hope your brother was not seriously injured. Towers are no place to fool around—everything must be perfect or there will be problems. I'm glad to hear that Trace was reasonable with your warranty problems. I'm surprised to hear that your installing dealers are making legal war on each other. Once the lawyers get involved, nobody seems to win. I salute you for sticking with RE after all those problems. I'll make you a deal—if you stick with RE, I'll keep on flying! Richard Perez

Two-Phase AC Outdated

In case you didn't already catch it… A few notes on *Electric Bills… Gone with the Wind,* by Tim and Corinne McCorkendale, from *HP75.*

In the electrical diagram they refer to a synchronous inverter that creates two-phase, 240 VAC. I think what they mean is two-leg single-phase AC, for a few reasons. Two-phase is a little-used form of power only offered to grandfathered factories in Philadelphia and maybe Detroit or New York City. It is never in residences, predates three-phase, requires five wires and ground most of the time, and was only used for a short time before three-phase was invented. It actually gives you 120 V or 208 V and you would have to use an autotransformer to get 240 V.

It is difficult to get a power company to give you two-phase, and it is incredibly powerful. I have only worked on a few two-phase systems, and I lived in Philadelphia my entire adult life. The smallest two-phase system I have seen is a 200 amp service, which is the equivalent to an 800 amp single-phase service. I think your readers might be interested. Turtle, Eastsound, Washington

Wanted: DC Clothes Washer

Dear *Home Power* people, I recently spoke with some of your staff about running a washing machine on DC power, and came away with dreams of inverters and Staber 2000s. This was a nice dream, but not very realistic for a DIY family of five on a tight budget.

Meanwhile, back at the farm, we continue to haul our laundry tonnage to the local rent-a-washer to the tune of about US$20 per week (not very financially or environmentally sustainable, in my mind).

After calling all of the appliance technicians in our area and only coming up with one who's mind could bridge the AC-DC chasm, I figured that the time had come again to beg info from the RE community. I have heard the "why don't you just use a generator or inverter" "solution" more times than I can count, but I can't bring myself to give up on this quest, knowing that its been done before *(HP25, Things that Work!).*

So, if anyone out there has info or possible leads to info on how to convert an AC washer to run off of DC power (homebrew style) or if you know the whereabouts of the guzzle buster guy, could you please send word. Joi Bailey-Saucy, PO Box 1124, Willamina, OR 97936

Hi Joi, Jim Forgette of Wattever Works, famous in the early days of Home Power *for his DC washing machine conversion kits, seems to have disappeared from our radar screen. How about it, readers, any ideas on DC conversion of AC washers? Michael Welch*

Hi Joi, I understand your dilemma. Our large family also went through years of hauling laundry to town. Then we stepped up (?) to an AC washer that we could only run when the generator was running. Later, I did convert a White-Westinghouse front loader to 24 VDC. By that time we had an inverter, so we could run the machine's AC controls through it. Converting to a DC motor used much less energy, but in retrospect, I'm not sure it was worth all the trouble of converting the machine. But then, I didn't pick the best machine to convert.

It's not a simple process, and I'd suggest that you think long and hard about other options. If you're sure that converting a machine to DC is the way to go for your family, start looking for an older but serviceable machine. You'll want something with a simple belt drive and a standard motor mount. Replace the AC motor with a good quality DC motor. Then find the control circuit that runs the motor, and wire in a relay to start the DC motor whenever the machine's controls call for motor action. You'll still need to have a small inverter to run the machine's AC controls.

Sound like a lot of trouble? It is! We've long since invested in a larger power system, and a Maytag Neptune washing machine. This machine is of much better quality than the Staber, and uses less energy per load (about 105 WH, after the inverter). Another option would be to look for a human-powered washer. I've seen some in catalogs from Lehman's and Cumberland General Store over the years. Best of luck with your problem, and do let us know how you solve it in the end. That US$20 a week, plus the cost of transportation and your time at the laundromat, could buy you a much more sustainable and convenient laundry system. Ian Woofenden

Solar Cooking Rah Rah

Dear *Home Power* staff, I have seen you folks for eleven years in Amherst and Madison, Wisconsin, and have subscribed for a decade and advertised for a few years. I had a great opinion of your work, but am now overwhelmed by your service to solar cooking on the *Home Power* Web site.

I am teaching an experimental course for three hours per week at the Fennville School District alternative ed school. I ordered ten copies of *Heaven's Flame.* The original copy with the red Chinese characters has been a prized possession that does not leave my home.

I will be using *Heaven's Flame* as a textbook, along with the Web. I never knew until now what an incredible resource you are providing. It's astounding! I will be using your Web links to show to the small number of staff, who are already intrigued. We have one south-facing window in the old red brick building. After we build Joe's SunStar, I want to order the plans for the Kerr Cole "through the wall" solar oven. The building has a small kitchen. I printed the page off the solar cooking archive plans page and will give it to the principal to see if he will consider it for a "capital improvement" for the building. If it ever happens, maybe I'll write a short article a year from now for the archives, or even for *HP.*

My appreciation of your work just got a lot deeper. I don't know how else to say… Thank you and don't ever let up! Richard Orawiec, Fennville, Michigan • btf@datawise.net

Hello Richard, The SunStar is a fun project. When I was proofing Heaven's Flame, *I became so intrigued that I had to build one. This project was right up my alley—I've been creating things out of recycled materials for as long as I can remember. This cardboard, tinfoil, and glass cooker was easy to make, and I finished it just in time to take it to MREF '98.*

I followed the SunStar design in the book, but I wanted my solar cooker to be portable. So I made some flat "buttons" (beer bottle caps hammered flat with two holes punched through), and sewed them to the bottom flaps of the cardboard boxes with heavy-duty upholstery thread. To set up the cooker, I close the boxflaps and wind a string around the two buttons in a figure eight. When I want to fold the boxes flat for easy transport, I just unwind the thread from around the buttons.

The first thing I cooked in my SunStar was a vegetarian zucchini lasagna. It makes my mouth water just thinking about it—that dish turned out great. When it was done cooking, a neighbor came over, wondering what I was doing with "that cardboard thing" on the porch. I explained to her what the cooker was and offered her some lunch. She couldn't believe that I had just cooked lasagna in a cardboard box, but was really excited by the wackiness of the idea, and was more than willing to sample some.

After I explained about the cooker, I told her the solar cooking noodle secret—don't cook the noodles first, just layer them in the pan with the rest of the layers, uncooked. She left with a full stomach and some new ideas to digest. I went to wash the empty pan, thinking that I was glad it was easy to wash solar-cooked dishes, because nothing is ever cooked so hot that it burns on the pan.

Education can really be fun. Sounds like you've got some great things lined up for your class. We'd love to hear from you and your class on any solar cooking projects you attempt. And of course, we'd love to see your article…. Joy Anderson

Global Warming Skeptics—a Finer Point

I take issue with one part of Richard Engel's otherwise excellent review of Ross Gelbspan's book, *The Heat Is On, HP78,* page 112. He calls those who doubt the emergence of global warming "skeptics." They are not, and the reason they are not is subtle but important.

Burning fossil fuels removes carbon from a reasonably secure source and dumps it into the atmosphere. There it enters a carbon cycle running in a time scale enormous compared to that for human culture. We thus transform our world. A set of transformations, rather than the world itself, becomes the abstract space for scientific endeavor.

Global warming detractors casually assume trivial consequences from our very non-trivial alterations. This assumption is without foundation. And for skeptics, in the traditional sense of that term, it is an assumption we cannot abide. I am grateful for your consideration of my thoughts. Henry Bruse, Wisconsin Rapids, Wisconsin

Out in Left Field

I have been a long time subscriber and booster of *HP.* But so much of your publication is such weird "Rheen" (old line red, now Green) politics that although I have loaned issues, and recommended your pub to many online, I don't think it has meant many if any subscriptions for you.

Problem is, as a sail enthusiast, and currently bus converter, most of my associates either work for a company or own the company. All are shocked by the anti-corporate rants and views on socialized power. Unfortunately, they are willing to throw out the grain because the chaff is so childish, to their eyes.

I am further saddened to see that you are beginning to review fiction. *The Heat is On* makes very sharp criticism of doubting scientists. As NASA is the prime debunker, merely by recording the global climate for two and a half decades, and posting the results, your view that "scientists" agree is crap.

Before your time, the bug doctor Paul Erdman (club of Rome) claimed in 1969 that by 1982 we would all be freezing in the dark. Still an expert to you folks although, the freezing winter con is now the global warming con! I know that you folks are wedded to a political view, rather than reality, but I have enclosed a reprint of an article for you to read and hate. [Ed. note: the article enclosed was "Some Like It Hot" from the April 2000 issue of *The American Spectator].*

Please keep up the good work in the things you do, but be advised your political views are costing you dearly with the 95 percent of Americans not waayyy out in left field. Fred Church, Middletown, Connecticut

Thanks for your letter, Fred. First, a couple of questions:

1. Where do you get the "h" in "Rheen"?

2. Assuming Home Power *does represent the leftmost 5 percent of Americans, doesn't being an* American Spectator *reader put you in the equally alienated rightmost 5 percent? (The American Spectator's 1998 circulation revenue was $6,065,764.80, which is probably more than* Home Power *rakes in, but at $12.95 a pop, that makes 468,398* Spectator *readers, or about two-tenths of one percent of the U.S. population. I'd say we're both pretty severely in the minority, Fred.)*

Kidding aside, I think the continuing departure of major oil and car companies from the global warming-denying Global Climate Coalition speaks louder than any statistics we can wave around. Since I reviewed Gelbspan's book, Daimler-Chrysler, Texaco, and General Motors have followed Shell, BP, and Ford in the rush for the exit. According to Worldwatch Institute's Lester R. Brown in his recent paper, The Rise and Fall of the Global Climate Coalition *(www.worldwatch.org/chairman/issue/000725.html), some of these companies have since joined the Business Environmental Leadership Council, which has issued a statement saying "We accept the views of most scientists that enough is known about the science and environmental impacts of climate change for us to take actions to address its consequences." Fred, these are not leftist nuts saying these things.*

For my part, I can't say whether global warming really is happening or not. I think that ultimately, it doesn't matter, because the kinds of actions we should be taking to address this alleged phenomenon are things we should be doing anyway: using less energy, polluting less, shifting to renewables, and protecting and restoring our forests. Amory Lovins of the Rocky Mountain Institute calls these "no regrets policies." Let's knock off the quibbling and get back to work. Richard Engel • chard_e@yahoo.com

Hello Fred, thanks for your comments. I set up the folks at Home Power *to do important work. Well, important in the short term for the critters that currently inhabit your planet. The reality is, I have all the time in the Universe. Earth may very well kill itself off due to the greed and incompetence of human life. But I will still be around, and Earth*

will once again become a thriving planet a hundred or two millennia after you guys off each other. Or at least it will until Ol' Sol goes supernova—I haven't made up my mind on that one yet.

In the meantime, do me a favor and help my short term goals by knocking off the baloney you are laying on my helpers. And by all means, please lay off the ultra right wing reading. It will only poison your mind and help set up Earth for certain doom (short-term, of course). Give the kind hippies at HP *a break—they are only doing my bidding. Jah (a.k.a. God, Buddha, Rah, etc.)*

Greetings, Fred, My view is a little different than my co-director at Universe Management & Support UnLtd. I think He was a bit hasty in chastising you for your views. But He has a history of throwing lightning bolts around willy-nilly, and even flooding people out. Please cut Him a little slack—running the universe is a tough job, and you can't bat 1,000 all the time.

The folks at Home Power *do have their own viewpoints, just as you do. I suggest that you give them room to hold their views, just as you want them to respect yours. A lot of folks on your planet seem to get stuck on a particular brand of religion, philosophy, or politics. This often becomes so prominent in their minds that they often lose sight of the larger goal. I think your letter makes a good point. If* HP *wants to appeal to the largest possible audience for renewable energy, they should tone down their particular reasons for promoting it. Using renewable energy is a great idea, no matter why folks do it. After all, we gave you only a limited amount of fossil fuels and uranium, while we set up the sun to keep going forever (at least in your terms).*

But it's also OK for people to come to renewables from different viewpoints. The goal is not for everyone down there to think the same way—that would be dreadfully boring, not to mention very unproductive. The goal is to figure out how to get along and make a harmonious and productive world. I suggest that you and the folks at HP *strike a deal: you both try to respect the other's viewpoint, and support everyone's right to express them. Gaia (a.k.a. Goddess, Hera, Earth Mother, etc.)*

Small Is Beautiful
I just loved "The Nerds Behind the Words" in *HP76.* I also appreciate the large page numbers and that they are on every page. I love the magazine, but seek more *simple* solutions to self-sufficiency. I'm looking for low cost, low tech systems that a novice can grow with. Some of us live contented lives of conservation instead of conspicuous consumption—reusing, repairing, recycling instead of replacing—doing without fancy elitist gadgetry.

E.F. Shumacher's "small is beautiful" philosophy of appropriate technology seems so sensible in a world run amok with greed and waste. Super products like the Ecofan (reviewed in *HP76)* seem few and far between. We need to hear more about products along this line to aid in simple living for those not interested in the stockmarket or wasting their meager retirement funds. Keep up the good work! Sandy Davis, Grand Rapids, Michigan

Hello, Sandy. I guess simplicity is relative. The main thrust of Home Power *is energy generated from renewable resources. To me, it doesn't get much simpler than solar electricity. To be sure, it requires high technology and money to make solar electricity a working reality. The journey of a thousand miles begins with a single step. We began our system here with a single PV module. Our system grew over the years as we could afford it.*

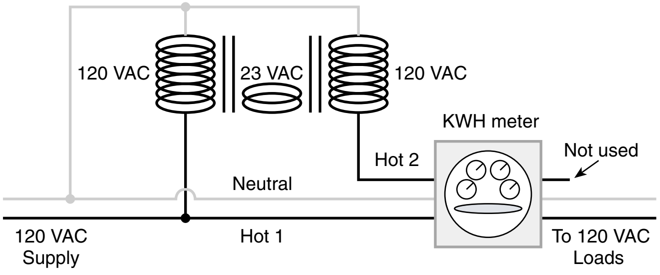
I can think of nothing I've bought in my life that delivers more satisfaction and value than a PV module. We have no money in the stock market and virtually no money set aside for retirement. We are perhaps as simple folks as you are. What you see is what you get. All of our energies go into this magazine. Our mission? Spread the word that the only energy source we need is the Big Nuke 93 million miles from here. I'll make a personal mission to include lower tech and less expensive energy products in these pages. Richard Perez

More Alternative Fuels Articles, Please
Your reader survey neglected to mention biodiesel! Michael Welch moderates a discussion list on biodiesel that got me to resubscribe to *HP.* I let my subscription lapse several years ago. Although interested in solar, I am very interested in methane, biomass, and biodiesel energy. So now you know why I am back. I look forward to receiving my new issue! Mark Richardson

Hello Mark, Home Power *is a hands-on users technical journal. We don't employ professional writers to deliver the information you see in these pages. The information we publish comes from our readers—it comes from hard-won personal experience. So how about it readers? I know some of you out there are working with alternative fuels. How about writing up your experiences and sharing the information with others? Richard Perez*

To take part in the biodiesel discussion list, send an email message to biodiesel-discussion-subscribe@topica.com. Michael Welch

Making 220 V KWH Meters Work On 115 V
Dear Richard, In *HP77,* on page 149, Jonny Klein (K7JK) asked about using 220 V KWH meters on 115 V. They will not run just using one 115 V leg of the meter. 220 V is required to make the clockwork tick. Fortunately, it only requires a couple of watts at 220 V to drive the meter mechanism. This is easily obtained using a 115 V isolation transformer to put a total of 220 V across the meter. The hookup is drawn below:



Rather than go out and buy an isolation transformer, a couple of filament transformers back to back will work fine if you have some lying around. ALL Electronics in Los Angeles (800-826-5432) has some 23 volt 1 amp transformers (Cat#TX-2312) for US$2 each, and two of those back to back will work fine. Just make sure the transformer output is phased so it's additive and you have a total of 220 V across the KWH meter. If you get it backwards, it won't hurt anything, the meter just won't run. Bob Grater K6SUB, Powell, Wyoming

Hello Bob, Thanks for sharing this fix with our readers. For another method of rewiring these KWH meters without using a transformer, see David Doty's article in HP17, *page 50. Richard Perez*

Code vs. Wrenches
Great magazine! We look forward to and enjoy every issue. Our 320 foot well is solar powered using a Dankoff pump. The house system components are being purchased. Much of the inspiration and design ideas have come from *Home Power.* Thanks!

Every time I read *Code Corner,* I see red (yep, just like the Communist color). Mr. Wiles and his ilk have taken on the task of protecting us and making us "safe." They do this by setting "standards," using selected testing laboratories (effective monopolies) to confirm component conformance to their standard. Then they wait while big government enforces their "rules"—all, of course, for our own good. This scheme seems to fit nicely with our society's lack of acceptance of responsibility. I do miss *Wrench Realities.* Those folks live in the real world as opposed to the bureaucratic world of big government with unlimited tax money to spend.

I would skip Mr. Wiles' writing altogether, except occasionally he has useful information (which makes him especially dangerous). I also believe that you should know your enemy, so I always read *Code Corner.*

I enjoyed the latest column, *PV Modules, Conductors & the Code.* I had a couple of observations concerning his analysis of a 24 volt PV system where he belittled the use of Square D QO circuit breakers. His logic being that, with "safety" factors, two typical PV panels exceed the Square D QO circuit breaker's 48 VDC rating. These breakers have a 240 VAC rating. Now I know what those bureaucrats would say—AC loads are easier to switch than DC loads, thus the different ratings. The key seems to me to be the word "load." If the PV panels are under load, even a small load, the voltage drops quickly. That is why the voltage used by Mr. Wiles is called "open circuit." No current is flowing and the breaker does not have to interrupt any load.

Shouldn't this be part of any "analysis"? After all, Mr. Wiles is funded by big government. If the circuit breaker does have to interrupt load, the voltage from the PV panels will be much less than Mr. Wiles would have you believe (more like 45 VDC). In fact, these breakers have a long history of success, even by Mr. Wiles standards, working in 24 VDC PV systems. And as Mr. Wiles indicated (in a demeaning manner), they are "inexpensive."

Finally, I wonder what the actual DC tolerance for the Square D breakers is? They were probably rated at 48 VDC because that has been an industry standard DC voltage. I suspect that in fact they could handle the 15 percent increase in nonsensical voltage proposed by Mr. Wiles, even if there were some current to interrupt. I worry that this kind of "analysis" and regulation runs up end-user costs with little or no impact on safety. I also worry about regulating based on transient weather (cloud cover, once a decade temperature or snow, etc.). Mr. Wiles and his group seem to want rules that cover every possibility, with the goal of fifty year faultless "safety," no matter what the cost. They ignore proving the need for regulation as shown by either a cost/benefit analysis or by review of field experience.

I sure wish you would reinstitute the original *Wrench Realities* format. Allow the writers to be anonymous so our big government could not retaliate against them. The old column format provided your readers a clear picture of the real world, just as *Code Corner* illustrates the big government approach.

Thanks again for a great magazine and for being brave enough to support independent "energy" action. Sincerely Walt Coffman, Muskogee, Oklahoma, khenderson@oknet1.net

Hello Walt. Most RE installers have a love/hate relationship with the NEC *and its requirements. On the one hand, we want our systems to be safe and able to be financed and insured; on the other hand, we want them simple and affordable. My guess is that the answer lies somewhere between totally covered and totally free. We'd love to have more* Wrench Realities *columns—you'll find one in this issue (page 84). As with all our editorial content, we are at the mercy of what our readers send us. How about it, wrenches, care to share your experiences? Richard Perez*

Federal Net Metering Bill

Dear *Home Power,* While searching the Web for information on net metering, I came across a bill (HR 2947, the Home Energy Generation Act) that was sponsored by Representative Jay Inslee. Basically it says "To amend the Federal Power Act to promote energy independence and self sufficiency by providing for the use of net metering by certain small electric energy generation systems, and for other purposes." According to the Thomas Web page there are 44 co-sponsors, and the last major action was that it was referred to the House Subcommittee on Energy and Power back in October of 1999. It seems that the federal government is trying to get involved in net metering.

Maybe it is time for readers of *Home Power* to take action and write to their representatives. I would hope that this bill would help pressure the utilities into cooperating with small energy producers and break the monopoly mentality.

The text of the bill is available for download on the Thomas Web site at http://thomas.loc.gov/cgi-bin/query/z?c106:H.R.2947, or on the downloads page of www.homepower.com.

This bill seems to be a step in the right direction. I'm curious to know *Home Power's* opinion on this bill. Does it have everything that is needed for net metering? Who will people go to if they still have trouble with the utilities? Thanks, Greg Thornwall, KD3SU thornwal@ncifcrf.gov

Hello Greg. The Inslee bill is a great start at standardizing net metering law nationwide. The terms are far better than most state net metering laws now in force. If this bill is reintroduced into next year's federal legislature, then it deserves our support. Getting this bill through Congress will take at least fifty times the effort we've expended on any state bill to date. This bill never made it out of committee during the 2000 congressional session. Hopefully it will be reintroduced during the 2001 session.

As you note, having such a law doesn't necessarily mean that utilities will comply with it. In Oregon, we've seen utilities refuse to comply with our state net metering law. See the article in this issue on page 58. First we must pass the law, then we must force utilties to comply with it on a case-by-case basis. This whole procedure is obviously going to take a very long time and require much effort from activists. Meanwhile, don't ask, don't tell, just push sell.... Richard Perez

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Ozonal Notes

Good Manners

Richard Perez

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I learned manners from my parents. High on their list of good manners are consideration of others and responsibility for your actions. Good manners allow us to coexist and cooperate with others. In all our relationships with people, critters, and our planet, good manners benefit us all.

Cleaning Up Our Mess

Burning dead dinosaurs has gotten us into big environmental troubles. We have made a global mess. We are sloppy energy eaters with very bad ecological table manners. Good manners dictate that we consider all that lives on our planet and stop making a mess. Then we must clean up after our century-long, fossil-fuel feeding frenzy.

Renewable energy sources do not have the pollution of combustion, or the deadly legacy of nuclear waste. Nature freely provides us with abundant energy in the form of sunshine, wind, and falling water. We must change our concept of fuel. Instead of waiting for our power to moulder underground for eons, we can graciously accept Nature's gifts as and when she offers them. To refuse these energies is the height of bad manners.

Our environment is dependent on the good manners of everyone living here. We have been unspeakably rude and crude to our planet and all lifeforms on her. We owe our world an apology. We must change our bad energy manners. Using renewable energy sources is no longer a matter of technology and money. It is a matter of changing attitudes and entrenched interests.

Instead of Fighting Over the Mess

Burning dead dinosaurs has gotten us into big political troubles. There's something about concentrated wealth that brings out the worst manners in humans. Contrast the concentrated ownership of fossil and nuclear fuels with sunshine, wind, and water. It is difficult to imagine "cornering the market" on sunlight or going to war over the wind.

Renewable energy sources are free and democratic. If we use these natural power sources, we have one less reason to make war on each other. War is the worst of all possible manners. War denies all consideration of others and refuses responsibility for despicable actions.

We Can Be Responsible for Ourselves!

Living beyond the power lines is what got most of us started with renewable energy. It wasn't until we lived with RE systems that we appreciated the freedoms associated with good manners. Good manners allowed us to live and work where we wanted, even if the location was impossibly distant from the power grid.

A renewable energy system now costs less than the price of one-quarter mile of new utility power service. Land without utility service is still less expensive than land that is grid connected. For thousands of renewable energy users, having the good manners to accept Nature's gift has allowed us to afford our homesteads. Many systems also electrify home-based businesses. The type of business, its size and profitability, is like any American business. All these home businesses lack is the power bill, the commute bill, and the office rent. Everything from magazines to turbines to soap to flutes are being made with renewable energy systems. It is very good manners to support yourself without harming others.

What we have learned from using these systems makes renewable energy applicable and effective anywhere. Even if you now rent your energy from a utility, you can practice good manners by using power wisely. Efficient appliances like compact fluorescents, efficient refrigerators, and solar hot water heaters give their users lower power bills. They also lessen the pollution produced by nonrenewable energy sources.

Some of the energy wasters we've uncovered are so simple as to be comical, and so thoughtless as to be disgusting. Consider the case of phantom loads. Phantom loads are appliances that appear to be off, but

instead are still alive and sucking up electricity 24 hours a day. Check out the clock in the microwave, the instant-on, remote-controlled TV, and the clock in the VCR. Good energy manners mean not wasting electricity on trivial and useless applications. I can wait 15 seconds for the TV to warm up—how about you?

Want a statistic to show you the insult of phantom loads? Consider that the average American household supports 1.45 KWH of phantom loads per day. America's phantom loads waste enough electricity to completely power the countries of Greece and Vietnam, with enough left over for Peru. Such is the depth of our insult to others. Good manners at our table are to take all you need, but please don't waste any.

From Responsibility Comes Dependability
Independent renewable energy systems are self-contained, naturally-sourced energy cells. Each supplies and is cared for by its users. Natural power sources are harnessed locally. The energy is both site-produced and site-consumed. Renewable energy sources, particularly photovoltaics, are magnitudes more dependable than centralized power generation followed by wide area distribution. Here is, indeed, a formula for responsibility and dependability—both very good manners.

From Dependability Comes Self-Sufficiency
Making your own power is the energy equivalent of growing your own food. Life is an inherently vague process. Today one may be in good health and employed. Tomorrow one may be sick and broke. A renewable energy source offers freedom from rising power costs and monthly power bills. Make your own power, become energy independent, and use free, nonpolluting, sustainable, peaceful, and dependable energy sources all at the same time. Good manners include each of us bringing our share to the table.

Good Manners Allow Us Freedom
Those with good manners are welcomed and at home anywhere. If we were to improve our manners, we would find a very different world welcoming us. We would find a world that is cleaner, more peaceful, more free, more dependable, and more self-sufficient. Such a world is a fitting home for generations of well-mannered children to share with multitudes of critters and plants.

Renewable energy people are not rocket scientists or millionaires or Zen masters. If we can practice good manners, anyone can. Nature is asking us, "Please?" It's good manners for us to reply, "Thank you!"

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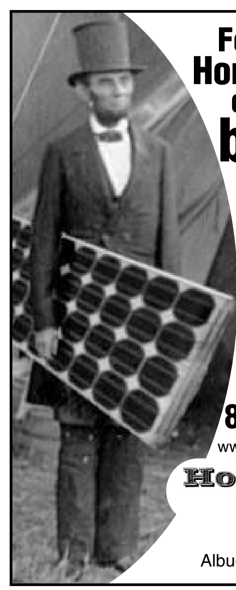
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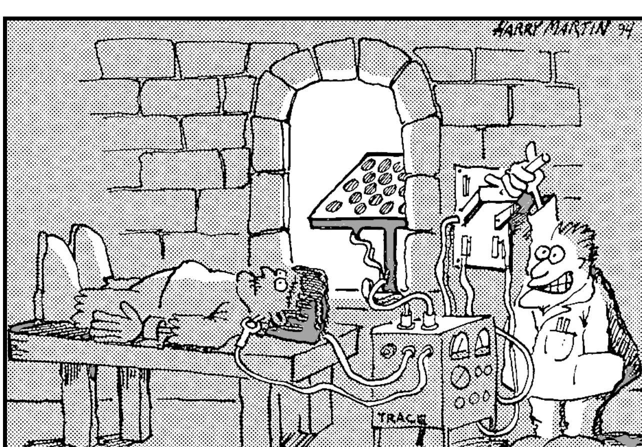

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Q&A

Running DC Loads From Your Computer's Battery

Hi Richard, I just came across an oddball problem with 12 volt power systems that your readers might like to know about.

Meg and I each have a Macintosh PowerBook, which we keep connected to our 12 volt house circuit through 12 volt adapters, one made by Lind Electronic Design, Inc and the other by Empire Engineering.

Neither of these adapters have blocking diodes to prevent reverse current flow. As I found out recently when working on a junction box, if you disconnect the circuit from the main battery while the computer adapters are still attached and there is another load on the same circuit, the computer batteries will discharge (fast) into the load.

Best wishes to all on the Flat. Ed Lachapelle Edlach@aol.com

Hello Ed, Yipes, and look out! This means that everyone with those two types of "power adapters" in automobiles is also using their PowerBook to start their cars! While this won't damage the computer, I imagine that it's hard on the computer's expensive battery. Richard Perez

Electronic Desulfators

Dear Mr. Perez, Please explain when to use an electronic desulfator in a lead-acid battery system. *Home Power* runs an advertisement that quotes you as follows, "'I consider (the PowerPulse devices) to be standard equipment for a lead-acid battery system...' Richard Perez, *Home Power* magazine" *(HP77,* page 107 and *HP78,* page 104).

But when I read about the new 24 V and 12 V systems that you designed for *Home Power,* I found no mention of a desulfator in pictures, diagrams, or text. Please clarify your present opinion on the appropriate use of this type of unit. Thanks, Richard Arena, Kensington, Maryland

Hello Richard. Yes, I consider electronic desulfators to be standard equipment for lead-acid batteries. There are currently three commercial manufacturers of these units and they all work. There is also a homebrew unit that works, and you can access data on this at www.shaka.com/~kalepa/desulf.htm

There are desulfators in both systems here. They just didn't make it into the schematic because they were installed after it was drawn. We originally had them in the 12 VDC system we had at the house for years, but it took a while to get them installed after the systems moved to the new power room.

These units operate by shattering the large sulfate crystals. Exactly how they accomplish this is still a matter of debate. The fact that they work is not. There have been extensive tests made by the U.S. Air Force and Hunt Foods (forklifts) demonstrating that desulfators work. Our experience here confirms this. Richard Perez

Rebuildable Batteries?

Dear Mr. Perez, I have 24 batteries made by C&D Battery Co., type KCT, 270 AH at the 8 hour rate, #1176J. These batteries will charge up to 2.2 volts or a little higher, but the specific gravity will only be 1125 or 1200. At that specific gravity, they will freeze in cold weather.

I have done mechanic work all my life, and probably have at least a basic knowledge of electricity. We as a family live without a lot of the conveniences that most people would consider necessities, and use these batteries as standby power for small jobs like typing this letter. I am usually able to do my own repairs, and want to know if there is something I can do for these batteries.

I charge these batteries with a small diesel engine that powers my shop tools and runs a Delco 90 amp alternator. I understand that these batteries are rebuildable. I would like any information you can give me. What happens when a battery won't take a charge anymore? What is repairable and what is not? Where can I get parts for my batteries? I hope to hear from you soon. Sincerely, Eli Mast, Pleasantville, Tennessee

Hello Eli, Consider giving those batteries a series of equalizing charges and installing an electronic desulfator. If they don't come back from the dead, then recycle them. Battery rebuilding is not for do-it-yourselfers. It's best left to the pros—it's dangerous and also extremely unlikely that a homebrewer can do an effective job. Richard Perez

Funky Batteries

I recently discovered a low battery voltage problem with my off-grid solar home. Even after a full day of charging (and lots of generator charging over the weekend), my battery voltage yesterday evening was down to about 12.0 volts. I have pretty much disconnected all phantom loads, so I don't think the house is the problem. The batteries are about 5 to 8 years old, so I am suspecting them at this point. Is it possible that one or more of them have gone bad, and is draining the system? If that is the case, how can I test to determine which ones are bad? Would a simple voltage check on each individual

battery answer that question, or do I have to put them under a load somehow? Any advice would be much appreciated. Roy D Surovec, Edwards AFB, California roy.surovec@edwards.af.mil

Hello Roy. Get a hydrometer and check the specific gravity of each cell after giving the pack another rigorous recharge. Full charge is SG 1.260. Anything less than 1.17 indicates a bad cell. It only takes one bad cell to render the whole battery bank ineffective. Richard Perez

Hydronic Loop Battery Cozy

Richard, *HP77* describes the hydronic loop driven by the 0.5 amp, 120 VAC Taco pump. Do you turn on the pump manually when the temperatures get cold, or is it controlled by a thermostat? Are there any other components in the loop like a check valve or expansion tank or pressure relief valve? Temperatures are getting lower in northern New Mexico so I want to build a battery warmer like yours. George Salvo gpsalvo@nnmt.net

Hello George, The pump is controlled by a conventional bi-metallic thermostat (made by Honeywell, and less than US$25 at any hardware store). There is no expansion tank, since the battery hydronic loop is part of our domestic hot water system.

The primary loops on this system are glycol/water with a heat exchanger to the 50 gallon tanks. The primary loops have an overtemp pressure valve, a pump, and an expansion tank. We have two of these systems each with its own collector, heat exchanger, and tank. Total capacity is 100 gallons.

The battery box is fed with the same potable water as the shower and the washing machine. It's about 140 to 180°F. Battery temperature stays at 74°F, ±2°F. Richard Perez

Oh, So That's How They Do It!

I have been told that the propane runs the motor in a propane refrigerator. The flame flows into a 1 inch hole in a box under the refrigerator. How does this run a motor? I was told propane ran a refrigerator much like propane runs a generator. A generator has a spark plug, so I don't understand.

I really, really would appreciate a somewhat detailed explanation, since this has puzzled me for years. I have a Servel that was produced in the 1950s. Thanks, Donald Orr • Don_Orr@jdedwards.com

Hello Don, There is no motor in a gas (propane) refrigerator. The refrigeration cycle in this type of unit uses heat to take the place of a motor. Omitting some of the minor details, here's how the freezer (or refrigerator) works:

1. The gas burner heats a solution of ammonia and water. The ammonia vapor is expelled from the solution, and then flows to the condenser (the cooling surface outside on the back of the fridge).

2. In the condenser, the ammonia is cooled to room temperature, where it becomes a liquid.

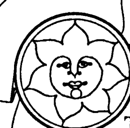
3. The cooled ammonia flows to the evaporator (the cooling surface inside the fridge and freezer). Hydrogen, from another vessel, is let into the evaporator. Since the hydrogen takes up some of the volume of the evaporator, the ammonia evaporates at a lower (partial) pressure. (This is an effect described by Dalton's Law.) The evaporation of the ammonia creates the cooling effect.

4. The combined hydrogen and ammonia vapors leave the evaporator and pass to the absorber. The ammonia is absorbed by the water. Hydrogen, which is basically insoluable, is released back to the evaporator again. Excess is stored in a reservoir at the top of the fridge. The heat of absorption is released through another heat exchanger.

5. The solution (ammonia and water) returns to the generator for reheating, to repeat the cycle. All steps are occuring simultaneously, whenever heat is applied to the unit.

6. An electric element can replace the propane flame, but it takes quite a bit of heat to operate. (A rough estimate is 200 BTU per hour per cubic foot of interior space. So a 7 cubic foot Servel takes 1,400 BTU per hour, or 33,600 BTU per day, or 10 KWH per day.) All this depends upon refrigerator construction and temperature settings, and ambient temperture.

There are many smaller steps in the process, and it is quite a marvel that refrigeration takes place! More detailed information is available in ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) Handbooks. Jeffrey Wolfe, P.E., Global Resource Options, LLP • global@sover.net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Index to Advertisers

Abraham Solar Equipment — 104
ABS Alaskan — 115
Adopt a Library — 119
Advanced Composting Systems — 87
Aeromax — 22
Alternative Energy Store — 66
Alternative Energy Systems Co — 115
Amazon Power Company — 140
American Solar Energy Society — 105
Applied Power Corporation — IBC
Aquadyne — 106
Arrow Specialty Company — 107
AstroPower — 21
BackHome — 123
Backwoods Solar Electric Systems — 57
BargainSolar.com — 89
Bergey Windpower — 31
Bogart Engineering — 95
Bountiful Energy — 20
BP Solar — 2
Brand Electronics — 80
BZ Products — 107
C. Crane Company — 119
CheapestSolar.com — 83, 121, & 123
Controlled Energy Corporation — 89
Creative Energy Technologies — 110
Dankoff Solar Products — 30
Electro Automotive — 123 & 140
Electron Connection — 49
Electronic Parts Outlet — 89
Energía Total — 126
Energy Conservation Services — 32
Energy Outfitters — 95
Energy Systems & Design — 40
EPOWER — 94
Exeltech — 40
Explorer — 111
GennyDeeCee — 111
Great Northern Solar — 140
Guerrilla Solar T-shirts — 68
Harris Hydroelectric — 115
Heaven's Flame — 68
Hitney Solar Products — 105
Home Power Back Issues — 128
Home Power Biz Page — 81
Home Power CD-ROMs — 56
Home Power Sub Form — 80
Home Power T-shirts — 68
Home Power Web — 140
Homestead Solar — 137
Horizon Industries — 115
Hydrocap — 87
Innovative Energy Systems Inc — 107
Intermountain Solar Technologies — 47
Invertrix Inc — 83
IPP — 127
Jack Rabbit Energy Systems — 66
KTA Services Inc — 75
Kyocera Solar Inc — OBC
Lake Michigan Wind & Sun — 99
Meridian Solar — 119
Monolithic Constructors — 111
Morningstar — 30
MREA Workshops — 57
New Electric Vehicles — 48
New England Solar Electric Inc — 105
Newinli International Inc — 48
Northern Arizona Wind & Sun — 80
Northwest Energy Storage — 55
Offline — 107
Planetary Systems — 39
Pony Enterprises — 127
PowerAssist.com — 119
PowerPod Corporation — 99
Preparation Enterprises — 121
Quick Start REading Special — 137
RAE Storage Battery Company — 99
Refrigeration Parts Solution — 123
Renewable Energy Videos — 68
RightHand Engineering — 46
Rolls Battery Engineering — 46
RV Power Products — 75
San Juan College — 127
Sawmill Publishing — 123
Siemens Solar Industries — 5
Simmons Handcrafts — 139
SMA America Inc — 32
Snorkel Stove Company — 48
Solar Depot — IFC
Solar Electric Inc — 110
Solar Electrical Systems — 111
Solar Energy International — 67
Solar On Sale — 87
Solar Pathfinder — 119
Solar Solutions Ltd — 121
Solar Village Institute — 56
Solar Wind Works — 73
Solar Works, Inc — 110
Solardyne — 83
Solarex — 23
SolarRoofs.com — 118
SolarSense.com — 9
Solstice Specials — 69
SOLutions — 79
SolWest Renewable Energy Fair — 127
Southwest PV Systems & Supply Inc — 75
Southwest Solar — 111
Southwest Windpower — 41
Statement of Ownership — 135
Sun Frost — 54
SunAmp Power Company — 66
Sunweaver — 30
SunWize — 56
Surrette Battery Company Ltd — 20
The Solar Guys — 123
Trace Engineering — 1
Transmagnetics Inc — 119
Trojan — 22
U.S. Battery — 33
U.S. Catalytic Corporation — 80
Vanner Power Systems — 4
Wattsun (Array Tech Inc) — 89
Wilderness Energy Research Systems — 104
Windstream Power Systems Inc — 107
Wood-Mizer — 111
Zephyr Industries Inc — 110
Zomeworks — 54

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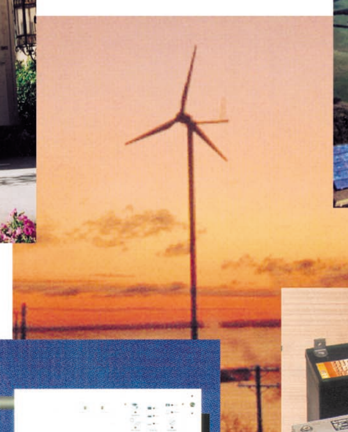

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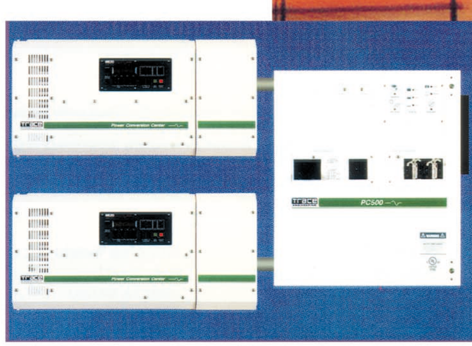

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NOW: I use renewable energy for (check ones that best describe your situation)

- ❑ All electricity
- ❑ Most electricity
- ❑ Some electricity
- ❑ Backup electricity
- ❑ Recreational electricity (RVs, boats, camping)
- ❑ Vacation or second home electricity
- ❑ Transportation power (electric vehicles)
- ❑ Water heating
- ❑ Space heating
- ❑ Business electricity

In The FUTURE: I plan to use renewable energy for (check ones that best describe your situation)

- ❑ All electricity
- ❑ Most electricity
- ❑ Some electricity
- ❑ Backup electricity
- ❑ Recreational electricity (RVs, boats, camping)
- ❑ Vacation or second home electricity
- ❑ Transportation power (electric vehicles)
- ❑ Water heating
- ❑ Space heating
- ❑ Business electricity

RESOURCES: My site(s) have the following renewable energy resources (check all that apply)

- ❑ Solar power
- ❑ Wind power
- ❑ Hydro power
- ❑ Biomass
- ❑ Geothermal power
- ❑ Tidal power
- ❑ Other renewable energy resource (explain)

The GRID: (check all that apply)

❑ I have the utility grid at my location.

I pay ______¢ for grid electricity (cents per kilowatt-hour).

____% of my total electricity is purchased from the grid.

❑ I sell my excess electricity to the grid.

The grid pays me _____¢ for electricity (cents per kilowatt-hour).

(continued on reverse)

I now use, or plan to use in the future, the following renewable energy equipment (check all that apply):

NOW	FUTURE		NOW	FUTURE	
❑	❑	Photovoltaic modules	❑	❑	Methane digester
❑	❑	Wind generator	❑	❑	Thermoelectric generator
❑	❑	Hydroelectric generator	❑	❑	Solar oven or cooker
❑	❑	Battery charger	❑	❑	Solar water heater
❑	❑	Instrumentation	❑	❑	Wood-fired water heater
❑	❑	Batteries	❑	❑	Solar space heating system
❑	❑	Inverter	❑	❑	Hydrogen cells (electrolyzers)
❑	❑	Controls	❑	❑	Fuel cells
❑	❑	PV tracker	❑	❑	RE-powered water pump
❑	❑	Engine/generator	❑	❑	Electric vehicle

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